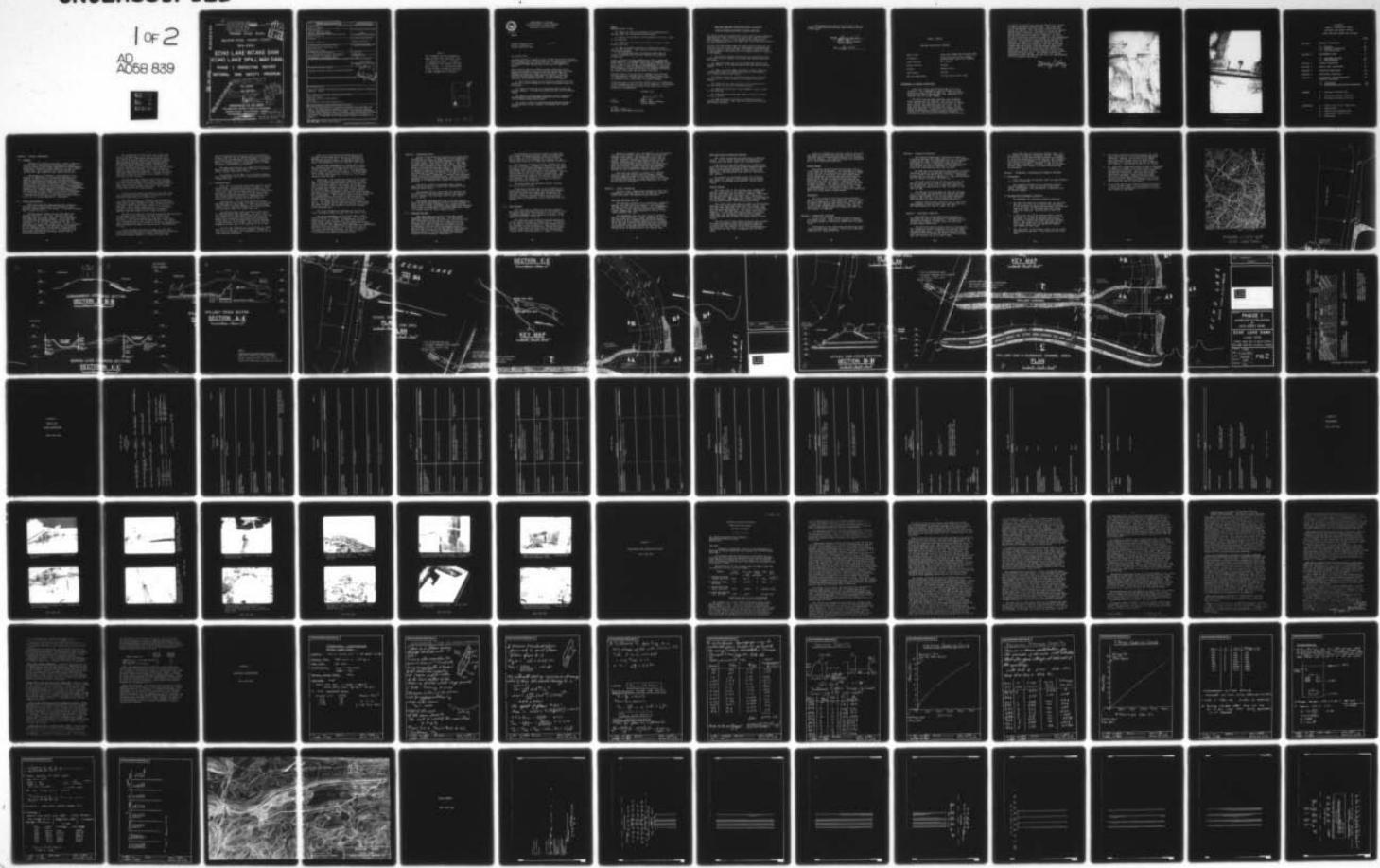


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Passaic River Basin Macopin River.
Passaic County, New Jersey.
Phase I Inspection Report.

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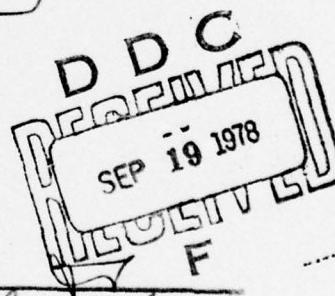
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NEW JERSEY

ECHO LAKE INTAKE DAM ECHO LAKE SPILL WAY DAM

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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IN REPLY REFER TO

NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

1 SEP 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Echo Lake Intake and Spillway Dams in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the condition of these dams is given on the first four pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Echo Lake Intake and Spillway Dams, high hazard potential structures, are judged to be in fair overall condition. Both dams are considered to have sufficient capacity to adequately handle the Probable Maximum Flood(PMF). To insure adequacy of both structures, the following actions, as a minimum, are recommended:

a. The following remedial actions should be initiated within three months from the date of approval of this report and completed within one year thereof.

(1) Repair the stone rip-rap on the spillway dam's approach and discharge channels. At the same time remove the brush from the discharge channel.

(2) Repair the spillway dam's deteriorated concrete sidewalls by strengthening the walls and anchoring them into the firm foundation rock to further stabilize the structure.

(3) Install a device for collecting floating objects upstream of the spillway dam to prevent clogging of the approach and discharge channels.

NAPEN-D

Honorable Brendan T. Byrne

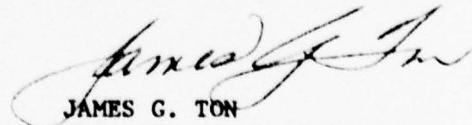
- (4) Remove the large rock obstruction at the downstream end of the road culvert over the spillway discharge channel.
- (5) Repair the deteriorated concrete wingwalls of the outlet conduit for the intake dam.
- (6) Rehabilitate the intake tower valves so they may be readily operated by one man.
- (7) Make an underwater inspection to determine the cause of inhibited gate operation. Clean, lubricate, and repair the gates and gate tracks as necessary.
 - b. The Cotters Brook diversion structures should either be repaired or demolished within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Robert A. Roe of the Eighth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,



JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

ECHO LAKE INTAKE AND SPILLWAY DAM (NJ00315 and NJ00558)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on various dates in June, 1978 by Langan Engineering Associates, Inc., under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Echo Lake Intake and Spillway Dams, high hazard potential structures, are judged to be in fair overall condition. Both dams are considered to have sufficient capacity to adequately handle the Probable Maximum Flood(PMF). To insure adequacy of both structures, the following actions, as a minimum, are recommended:

a. The following remedial actions should be initiated within three months from the date of approval of this report and completed within one year thereof.

(1) Repair the stone rip-rap on the spillway dam's approach and discharge channels. At the same time remove the brush from the discharge channel.

(2) Repair the spillway dam's deteriorated concrete sidewalls by strengthening the walls and anchoring them into the firm foundation rock to further stabilize the structure.

(3) Install a device for collecting floating objects upstream of the spillway dam to prevent clogging of the approach and discharge channels.

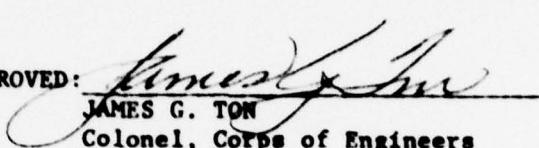
(4) Remove the large rock obstruction at the downstream end of the road culvert over the spillway discharge channel.

(5) Repair the deteriorated concrete wingwalls of outlet conduit for the intake dam.

(6) Rehabilitate the intake tower valves so they may be readily operated by one man.

(7) Make an underwater inspection to determine the cause of inhibited gate operation. Clean, lubricate, and repair the gates and gate tracks as necessary.

b. The Cotters Brook diversion structures should either be repaired or demolished within one year from the date of approval of this report.

APPROVED: 
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: Sep 1978

PHASE 1 REPORT

NATIONAL DAM SAFETY PROGRAM

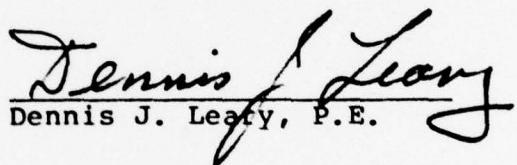
Name of Dam:	ECHO LAKE INTAKE AND SPILLWAY DAMS
ID Numbers:	Intake Dam; Fed ID No. NJ00315 Spillway Dam; Fed ID No. NJ00558
State Located:	New Jersey
County Located:	Passaic
Stream:	Macopin River
River Basin:	Passaic
Date of Inspection:	7,12,20 and 27 June, 1978

ASSESSMENT OF GENERAL CONDITIONS

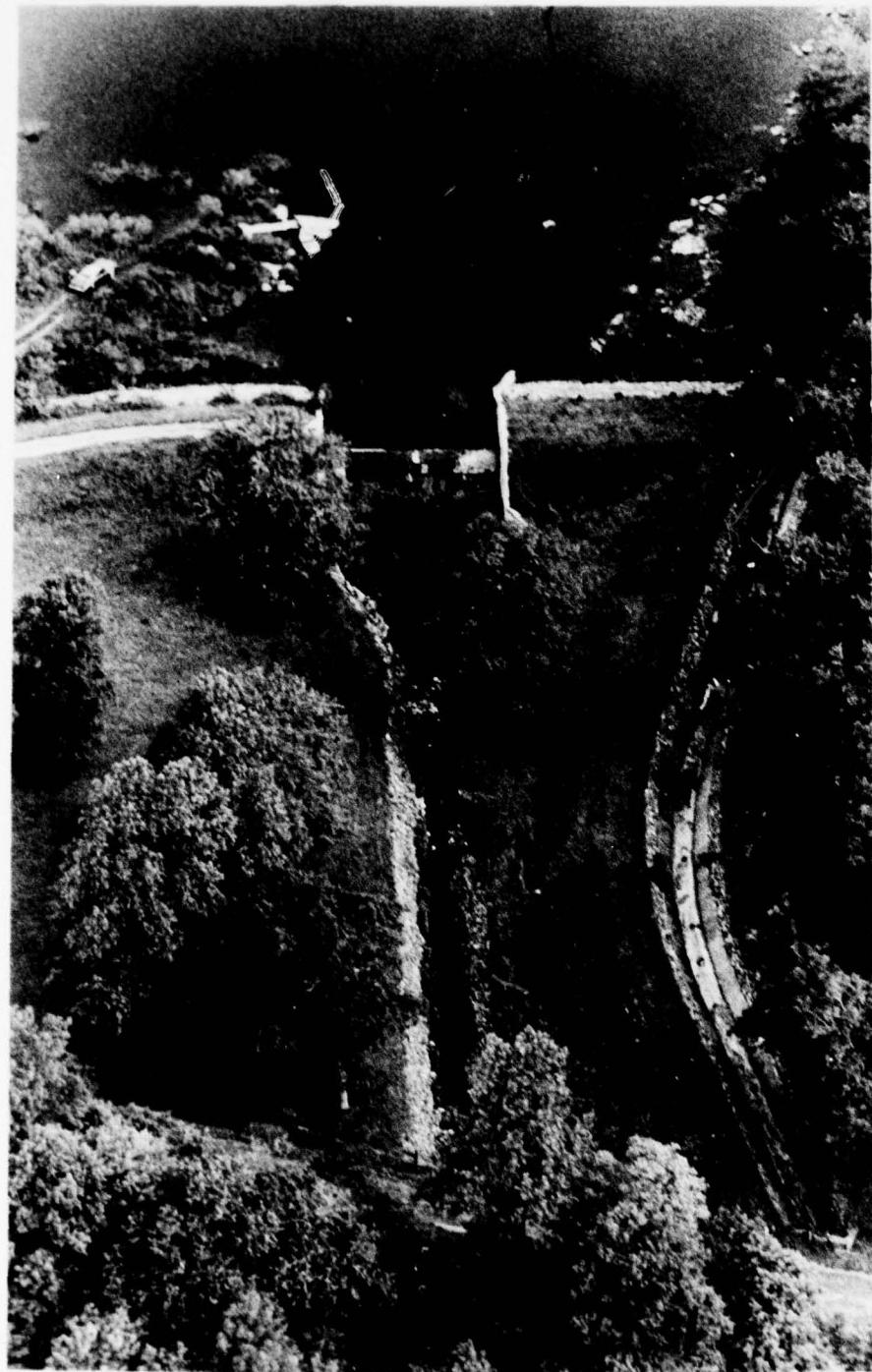
Echo Lake Intake and Spillway Dams are in fair condition. Our recommended remedial measures do not question original design assumptions. They are mainly related with repair, maintenance, and improvement to decrease risk of further damage.

The Echo Lake spillway sidewalls and discharge canal rip-rap must be repaired. The first priority is to rebuild the side walls of the spillway by making them stronger and anchoring them into rock. At the same time the upstream and discharge canal rip-rap should be repaired. In addition, all vegetal growth should be permanently removed from the discharge canal. A device for collecting floating debris should be installed as soon as possible upstream of the spillway.

It should be assumed that floating debris will include row boats and newly uprooted trees. The large rock at the downstream end of the culvert below the road should be removed. The wing walls of the outlet culvert should also be repaired. The control valves at the dam spillway and trash rack structures are in well maintained operating condition. However, the valves at the intake tower should be brought up to an operational efficiency that requires only one man to operate this station. An underwater inspection should be made to determine if debris or buildup in the gate tracks is binding and inhibiting operation, and the gate tracks cleaned and lubricated. The stem guides should have bronze bushings installed and the stems should be lubricated. Should the above allow for one man valve operation then this is all that should be done to these occasionally used valves. We estimate the dam can adequately handle the PMF and there will be approximately 1 ft of freeboard remaining.

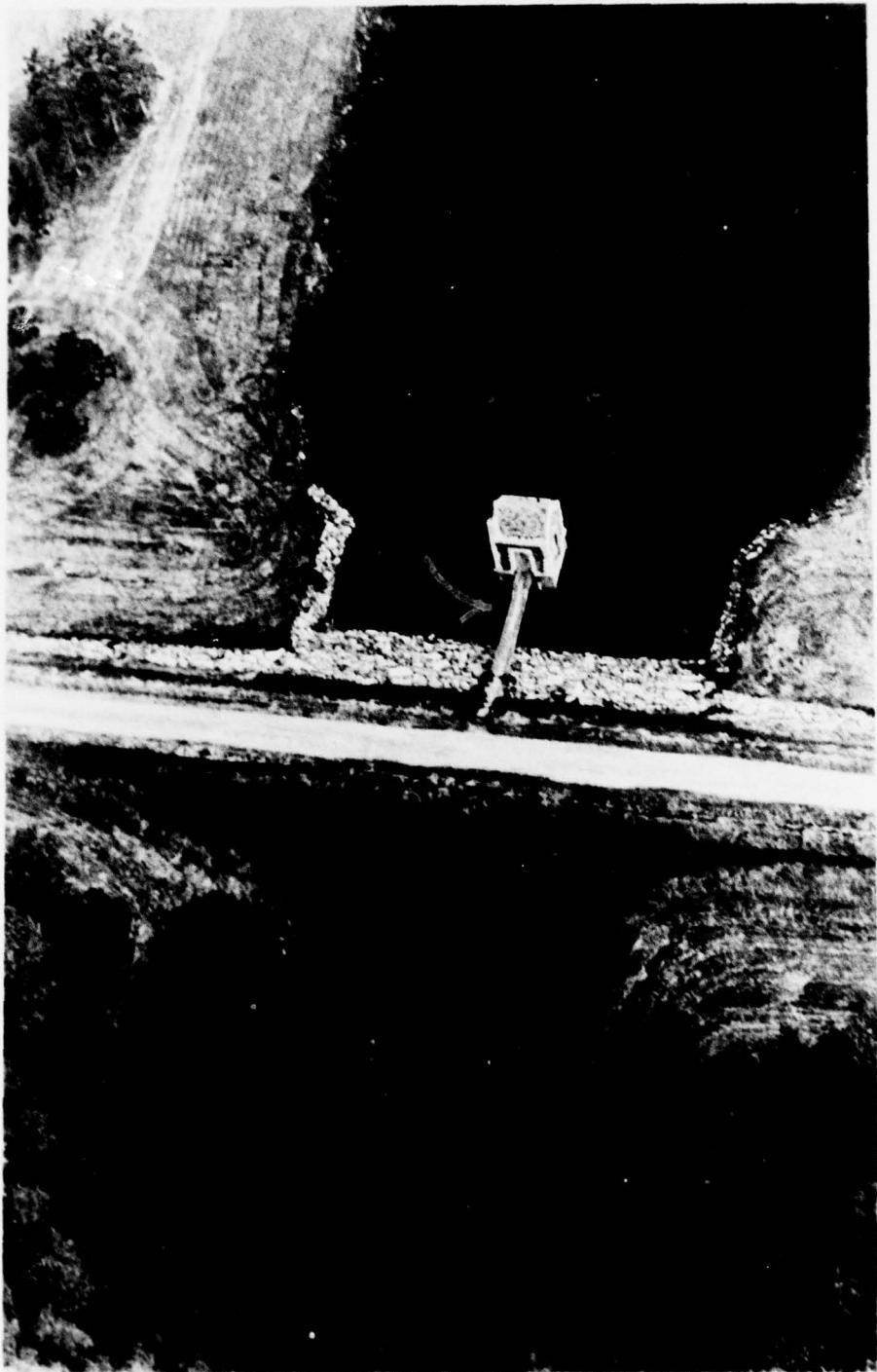


Dennis J. Leahy, P.E.



OVER VIEW
DAM AND SPILLWAY
ECHO LAKE SPILLWAY DAM

21 June 1978



OVER VIEW

DAM AND OUTLET STRUCTURES

ECHO LAKE INTAKE DAM

21 June 1978

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NATIONAL DAM SAFETY REPORT
ECHO LAKE DAMS INTAKE AND SPILLWAY

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SECTION 1 PROJECT INFORMATION

1.1 General

Authority to perform the Phase 1 safety inspection of Echo Lake Intake and Spillway Dams was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 26 May 1978. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367.

The purpose of the Phase 1 investigation is to develop an assessment of the general conditions with respect to safety of Echo Lake Intake and Spillway Dams and appurtenances based upon available data and visual inspection, and, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment is made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection to imply that a dam meeting or failing to meet the screening criteria, is per se, certainly adequate or inadequate.

1.2 Project Description

Echo Lake Dams and appurtenances are located at the south end of Echo Lake in the Township of West Milford, Passaic County, New Jersey. A regional vicinity map is given in Fig. 1.

The structures consist of two earth dams. The spillway dam with a free-fall concrete ogee type spillway; and the Intake Dam with outlet structures. Both dams have discharge channels. The Intake Dam is located at the southwest corner of the Lake at longitude $74^{\circ} 24' 43''$ and latitude $41^{\circ} 03' 00''$. It consists of an earth dam, intake tower, outlet structure, and discharge channel. The Spillway Dam is located at the southeast corner of the Lake at longitude $74^{\circ} 24' 25''$ and latitude $41^{\circ} 03' 00''$. It consists of an earth dam, spillway and discharge channel, and an unused diversion canal.

The Intake dam is 370-ft long, 32-ft high and has a 12-ft-wide crest at el 904. The intake tower is located 60 ft upstream of the dam and has gates that can be placed at different elevations to permit drawing better quality water from selected depths. The intake has an approach channel extending 1,870 ft into the lake to contour el 870. A reinforced concrete conduit passes through the dam from the intake tower to the outlet channel. The outlet channel is 1,870 ft long, has its bottom at el 872 at the dam and feeds Charlotteburg Reservoir. A valve and trash rack are located on the side of the channel to divert the water to the reservoir.

The Spillway dam is 450-ft long and 15-ft high. Its crest is 10-ft wide and at el 902. The spillway is a 50-ft-long concrete, free-fall ogee type spillway with its crest at el 893 or nine feet below the dam crest and at about present lake level. The spillway allows the use of 3-ft flash boards.

In 1897 Cotters Brook was diverted into Echo Lake. This diversion has been closed at the entrance of the diversion canal and is no longer used.

The intake structure, spillway, and embankments were built in 1926 together with the outlet canal that feeds Charlotteburg Reservoir. Under present conditions the need to feed Charlotteburg Reservoir is only occasional. Two or three times a year, 5 to 10 million gallons a day are drawn from Echo Lake by means of manually operated valves in the intake structure.

The Echo Lake Dams are classified as being "Intermediate" on the basis of its reservoir storage volume, which is more than 1,000-acre feet, but less than 50,000-acre feet. They are classified as "Small" on the basis of total height, which is less than 40 feet. The overall size classification is the larger of these two determinations, and accordingly the dams are classified as "Intermediate" in size.

In the National Inventory of Dams, the Echo Lake Dams have been classified as having "High Hazard Potential" on the basis that failure of either dam would cause excessive property damage to residences downstream,

and could potentially cause more than a few deaths. Visual inspection of the downstream shows that breach of either of the dams would cause damage to residences and be hazardous to people using Echo Lake Road and Route 23. Accordingly, it is proposed not to change the Hazard Classification Potential.

The dams and reservoir are owned by the City of Newark, Newark Water Department, City Hall, 920 Broad Street, Newark, New Jersey, 07102.

The purpose of the dams is to provide emergency water supply when the level of Charlotteburg Reservoir becomes too low.

1.3 Pertinent Data

Echo Lake is oriented north-south and has an area of 282 acres. Its maximum length is 8,000 ft. With Cotters Brook diversion closed the drainage area is 2.73 sq mi. The full storage capacity is 1,583 million gallons or 4,870 acre-ft between el 893 and el 872. The storage capacity increase is approximately 300 acre-ft per foot of height above spillway crest. Essential project features are given in Fig. 2.

Spillway Dam - The spillway dam has a weired spillway with an ogee shape. Vertical steel bars have been provided for flash boards. The total spillway length is 50 ft and was designed for a flood of 1560 cfs with water level 4 ft above the crest.

The maximum known flood occurred in 1903 prior to construction of existing dams. The water level was raised from el 892 (normal water level at the time) to el 898 or 4 ft below the present dam elevation. Normal pool elevation corresponds to the elevation of the crest of the spillway at el 893 and tailwater at the spillway is at el 882. The crest of the embankment on each side of the spillway is at el 902.

On the right abutment of the spillway is a valve with a 16 in. by 24 in. outlet opening. Access to this valve is through a pit located at the top of the right spillway side wall.

There is no stilling basin downstream of the spillway and dissipation of energy is provided by boulders in the river bed. The flood delivered by the spillway passes through an underpass below the road. The foundation and river bed are sound rock.

The spillway embankment is a homogeneous earth dam founded on dense sand and gravel with a cut off trench to bedrock. Its height is 15 ft from crest to toe near the spillway side walls. The approximate total length at crest level is 450 ft. The top width is 10 ft and side slopes are 2.5 hor to 1 vert with upstream stone paving.

Intake Dam - The outlet structures of the Intake dam, from upstream to downstream, comprised a trash rack; front gates opening inside the intake tower and set at different levels; and 2 gates for closure of each of the two conduits. The gates can be operated to withdraw water from selected elevations. Access to the gate house (floor at el 900) is from stairs starting from the embankment crest and an access bridge. The intake tower is approximately 60 ft from the centerline of the embankment. The concrete conduits as seen from the downstream outlet consists of two rectangular conduits having a total cross-sectional area of 100 sq ft. The length of the culvert is approximately 120 ft. An intake channel upstream of the intake tower has been excavated for a length of 1870 ft to a bottom elevation of 870. The bottom of the outlet channel is at elevation 872.

The outlet channel was designed to carry 93 ft³/sec. and can be used to lower the lake water level.

The earth embankment of the Intake Dam is about 370-ft long and is founded on bedrock. It has a crest width of 12 ft. at el 904. The embankment is 32-ft high between crest and bottom of the reinforced concrete outlet channel which is approximately 10 ft below natural ground. The embankment was designed as a homogeneous dam with a cut off trench. Side slopes are 2 hor to 1 vert on the downstream face; 1.5 hor to 1 vert at the upper part of the upstream face and 2.5 hor to 1 vert below with paved rip-rap protection.

SECTION 2 ENGINEERING DATA

Design of the existing structures were made mainly in 1896 and in 1926. As mentioned in the description, the diversion of Cotters Brook designed in 1896, is no longer used. This diversion dam has a very small storage capacity (less than 2 acres feet). The 1926 Construction drawings of Echo Lake are available with monthly construction progress reports. Descriptions of the main lines of the 1926 scheme is outlined in a "Report of Hydraulic Engineers" dated March 14, 1926 and addressed to James W. Costello. A copy of this report is included in Appendix 3 together with abstracts of the construction specifications. From the available documents we have determined the design and construction practice to be adequate with respect to present day practice.

The lake is used for emergency water supply. Under these conditions, normal pool elevation is the spillway crest level.

The maximum flood to pass over the spillway was estimated at a time when the catchment area was 4.35 sq mi. However, the catchment area is now reduced to 2.73 sq mi.

The normal upstream water level was designed to be occasionally increased by using 3-ft-high flashboards. There is now a large freeboard, 9 ft, above spillway crest which, without freeboards and assuming the necessary repair work is performed, will provide additional safety in a design which by itself appears sound.

2.1 Regional Geology

Echo Lake Dams are located in the New Jersey Highlands physiographic province. The New Jersey Highlands extend across the state in a northeast southwest direction from the border of New York to the Delaware River and includes the northwest portions of Hunterdon, Passaic, and Morris Counties and the southeastern parts of Warren and Sussex Counties. This province is part of the New England Physiographic Province and lies between the Appalachian Ridge and Valley Province to the northwest and the Piedmont Province to the southeast. See Fig 3.

The Highlands are characterized by rounded and flat-topped northeast-southwest ridges and mountainas up to 1,400 ft high separated by narrow valleys. The orientation of the valleys are usually, but not always controlled by the underlying geologic structure.

The regional geologic structure reflects the very old age of bedrock. A number of regional faults cross the area in a northeast southwest direction, including the Ramapo Fault; the more than 30 mile long fault scarp forms the eastern border of the province. Faults control many of the river valley orientations. The relatively uniform slope of the mountain elevations, from northwest to southeast, is a direct result of the faulting. The entire area is part of the now dissected Schooley Peneplain.

The Pleistocene Age Wisconsin glacier covered all of the dam site area.

The glacier stripped most of the existing overburden and weathered rock and uncovered the numerous hard bedrock knobs and ridges seen throughout the province. Most of the side-slopes in the area are covered with heavy boulder tills (ground moraine), whereas glacial outwash and recent alluvium cover the valleys.

2.2 Site Geology

Echo Lake Dam is located in the north-central portion of the Highlands Province, at the eastern foot of Kanouse Mountain. The reservoir lies in a long northeast-southwest valley which is a product of the underlying geologic structure.

The lake basin was formed by the obstruction of a river valley by means of glacial drift. The drift at the south or outlet end of the lake takes the form of a hardpan overlaying bedrock. Test borings show bedrock to be seven to thirty feet, below the ground surface except near the center of the valley where a driven well disclosed rock at a depth of 120 feet.

Bedrock throughout the area appears to be relatively shallow in the valley, and at or near the surface the adjacent side slopes. The predominant rock type is a light to heavily banded, excellent quality granite gneiss. However, the borings taken as part of the original investigation in the 1920's, describe the rock at the overburden-bedrock contact as "seamy rock" which we interpret to mean fractured and weathered. One boring in the embankment section describes the bedrock at that location as "decayed pegmatite".

Overlying the bedrock is glacial till (ground moraine), sand and gravel glacial outwash, recent alluvium composed primarily of sand and gravel and, in the spillway section, a "loam and clay". The latter may include lacustrine materials deposited in a lake as the glacier retreated.

SECTION 3 VISUAL INSPECTION

The site visit inspections included the Echo Lake embankments, spillway and outlet structures, control valves and gates, and Cotters Brook diversion.

Echo Lake Spillway and Dam

The concrete spillway is in serviceable condition. However, the side walls are broken at the upstream toe due to earth and riprap thrust. As a consequence, the rip-rap in this area has suffered local slides. A minor seepage has been observed at the toe of the right abutment side wall.

The embankment does not show signs of movement and is in good condition. Minor sloughing of the riprap has occurred in the spillway discharge channel. The culvert of the discharge channel of the spillway below the road is partially obstructed with a boulder. It is reported that this underpass has been partially obstructed by driftwoods during the 1903 flood. This occurred prior to construction of the present dam.

Echo Lake Outlet Structures and Dam

The outlet structures are generally in good condition. A water level staff gage is located at the intake tower and water levels are recorded daily.

Some trace of moisture appears at a construction joint on the left side of the intake discharge culvert about two feet above downstream water level. Minor seepage was observed outside the culvert along the left wall. The downstream wing walls of the culvert have failed.

No evidence of landslides within the reservoir were observed. However, the presence of the forest may result in problems with floating debris during floods.

Control Valves

The right side of the spillway has a Rodney Hunt control valve which at one time was used to supply make-up from Echo Lake to Macopin. However, this valve has not had functional use since 1960. Since then all Newark water supply has been treated at Charlotteburg and not Macopin. The Rodney Hunt valve, Shop No. 303, is functional however, and has been maintained.

The intake tower for make-up runoff to Charlotteburg Reservoir has three Rodney Hunt control valves. Two are Type 2504, Shop Nos. 320 & 321, with single ratio floor stand crank operators. The third is a Type 2512, Shop No. 317, with two gear ratio floor stand crank operators. The valves are operated only a couple of times each year and operate with great difficulty requiring three men to start the gates moving in their tracks.

The rear wall of the intake structure has a pulley and gear arrangement which was originally designed to facilitate the lowering of auxiliary gates for servicing the valve plate, track, and stem assemblies. Indications are that this arrangement has not been used.

There is a Rodney Hunt control valve at the trash rack intake structure for diversion of make-up water from Echo Lake to Charlotteburg Reservoir or emergency runoff to Macopin. The valve and trash rack structure are in well maintained condition.

Cotters Brook

The Cotters Brook diversion structures are in a poor state of maintenance. The spillway is founded on the rock and is constructed of large masonry stone without mortar or the mortar has been washed away. A flow estimated at 300 gpm was passing through the stones while 100 gpm was spilling over the crest. The diversion inlet is closed by wood stoplogs and backfilled upstream with earth. Leakage through the stoplogs is small. The wood of the stoplogs is still in good condition. The closure level of the intake is approximately six inches above water level. The canal downstream of the intake is covered by vegetation and is in a poor state of maintenance.

Evaluation

With the exception of Cotters Brook diversion and the spillway and culvert walls the essential structures are generally in good condition. Repairs must be made to the spillway and culvert walls. No traces or significant seepage were observed. The control valves at the intake should be improved so that only one operator is required.

SECTION 4 OPERATIONAL PROCEDURE

A daily visit of the intake is made to record lake water levels. There are no automatic recording or warning system to record any sudden raise of water level.

Maintenance of the structures and operating facilities are made when necessary. There are no periodic inspections or instrumentation.

SECTION 5 HYDRAULIC/HYDROLOGY

The hydraulic/hydrologic evaluation is based on a spillway design flood (SDF) equal to the full probable maximum flood (PMF) in accordance with the evaluation guidelines for dams classified as high hazard and intermediate in size. Available records indicate that the spillway and dam are designed on the basis of a flood flow significantly less than the PMF.

The PMF has been determined by developing a synthetic hydrograph based on the maximum probable precipitation of 22.5 inches (200 square mile - 24 hour). Hydrologic computations are given in Appendix 4. The PMF determined for the subject watershed is 11920 cfs.

The crest elevation of the dam is such that the dam can store water to height 9 ft above the crest of the spillway. With 9 ft of head the capacity of the spillway is approximately 5016 cfs which is less than the SDF.

The PMF was routed through the dam and spillway and it was found the dam would not overtop and there would be approximately 1 ft of free board remaining. Based on the routing it can be concluded that Echo Lake Dam does not have an overtopping potential.

Drawdown calculations indicate that it would take approximately 6 days to lower the lake level by 9 ft and approximately 14 days to empty the lake.

SECTION 6 STRUCTURAL STABILITY

The stability of the Echo Lake structures as determined by visual observation and examination of available records is satisfactory. The operating conditions with respect to water level are less than project design conditions.

The diversion dam at Cotters Brook is satisfactory with respect to overall stability but requires repair and maintenance work. It should be noted that these structures have withstood the adverse conditions that have occurred over the last 80 years and it is unlikely they will continue to do so much longer.

Echo Lake Dams are located in Seismic Zone 1 of the Seismic Zone Map of Contiguous States. The degree of stability of the dam and appurtenances are assumed to be within conventional safety margins and to present no hazard from earthquakes. If, however, the Seismic Zone rating is seriously increased in the future, or data becomes available to indicate it may be increased, further study with respect to seismic stability may be necessary.

SECTION 7 ASSESSMENT, RECOMMENDATION/REMEDIAL MEASURES

7.1 Assessment

Echo Lake Intake and Spillway Dams and appurtenances are in fair condition.

The remedial measures do not question original design assumptions. They are mainly related with repair, maintenance, and improvement to decrease risk of further damage.

7.2 Recommendations/Remedial Measures

We recommend the following remedial measures:

1. The Echo Lake Spillway sidewalls must be repaired. The first priority is to rebuild the side walls of the spillway by making them stronger and anchored them into rock. At the same time the rip-rap should be repaired. This should be done very soon.
2. A device for collecting floating debris should be installed as soon as possible upstream of the spillway. It should be assumed that floating debris will include row boats and newly uprooted trees. The large rock at the upstream side of the culvert below the road should be removed. This should be done soon.
3. The wing walls of the outlet culvert at the Intake Dam should be repaired. This should be done very soon.

4. The control valves at the dam spillway and trash rack structures are in well maintained operating condition. However, the valves at the intake tower should be brought up to an operational efficiency that requires only one man to operate this station. This should be done in the future.
5. An underwater inspection should be made to determine if debris or buildup in the gate tracks is binding and inhibiting operation, and the gate tracks cleaned and lubricated. The stem guides should have bronze bushings installed and the stems should be lubricated. Should the above allow for one man valve operation then this is all that should be done to these occasionally used valves. This should be done in the future.
6. Do not keep the Cotters Brook diversion structures in their present state. If the diversion is not to be used, we recommended demolishing it entirely. This should be done soon.



REGIONAL VICINITY MAP
ECHO LAKE DAMS

Fig 1

J

910

Downstream

900

890

880

EMBANKMENT-CROSS SECTION

0 10 20

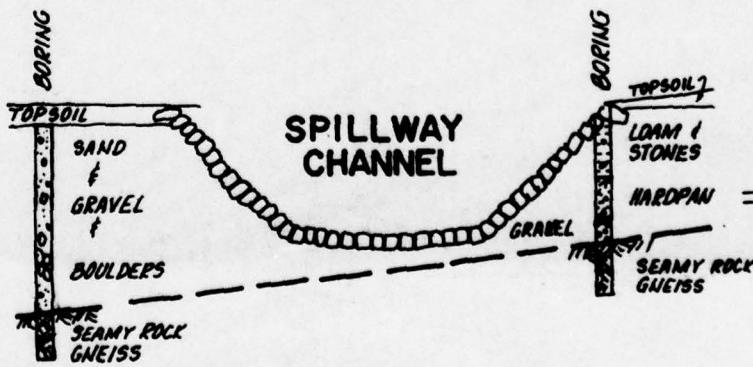
ELEV IN FEET

910

900

890

880



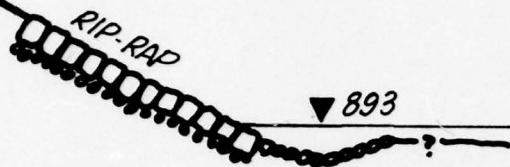
BORING LOGS / C SECTION

0 10

3
ELEV. IN FEET
U.S.G.S. DATUM

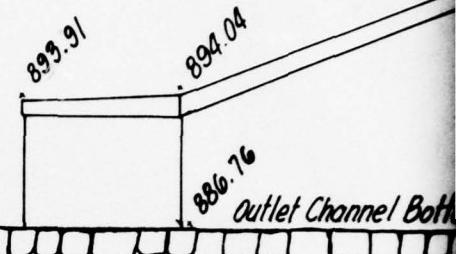
910

Upstream



Downstream

900



CROSS SECTION

B-B'

30 ft

890

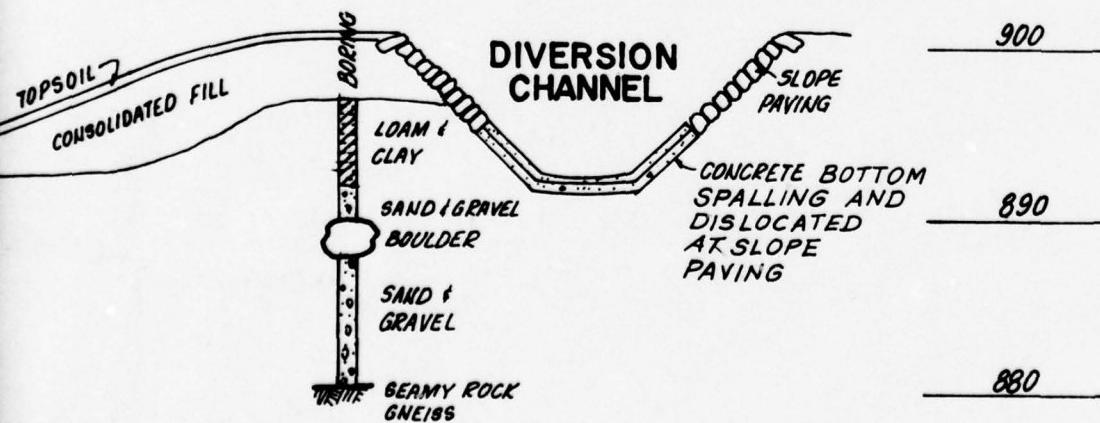
880

870

910

SPI

S

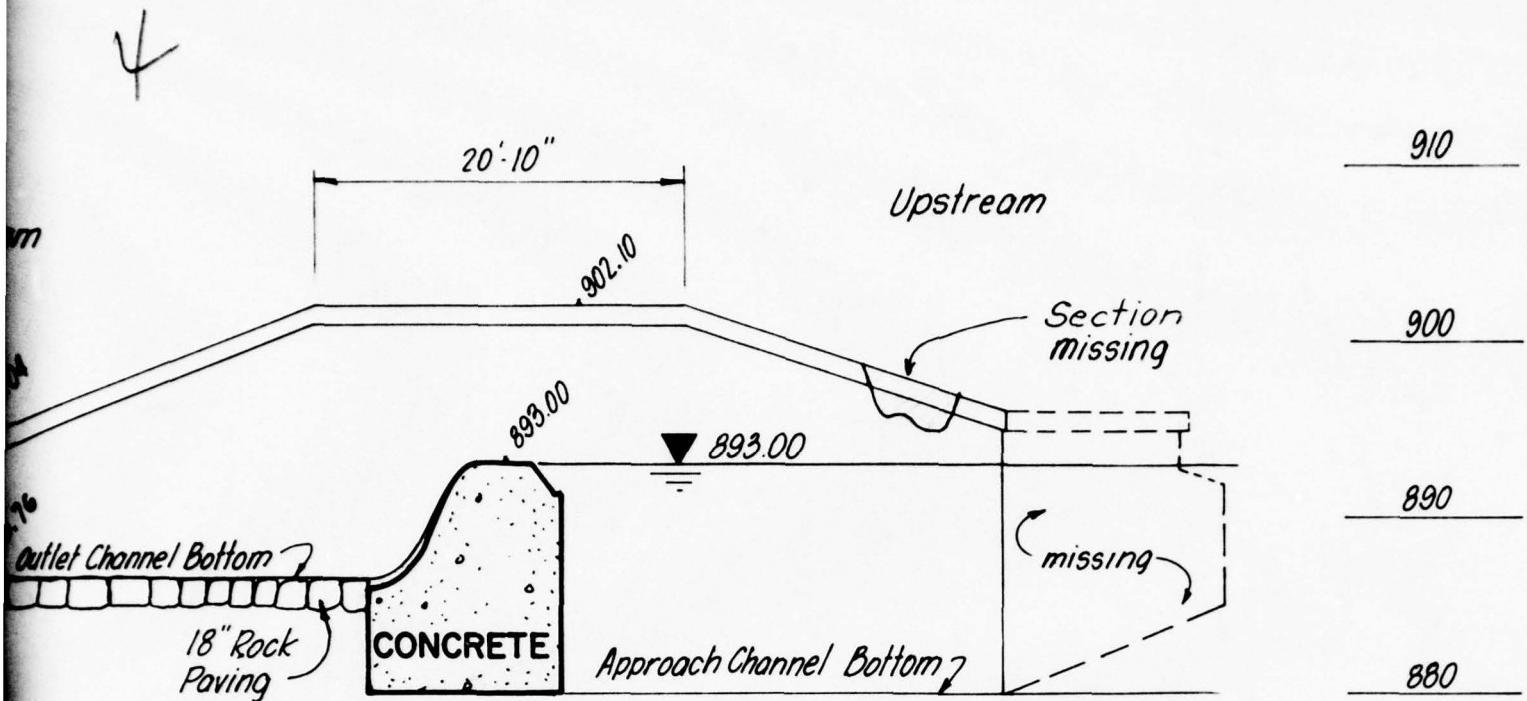


CROSS SECTIONS

N C-C'

20

30 ft



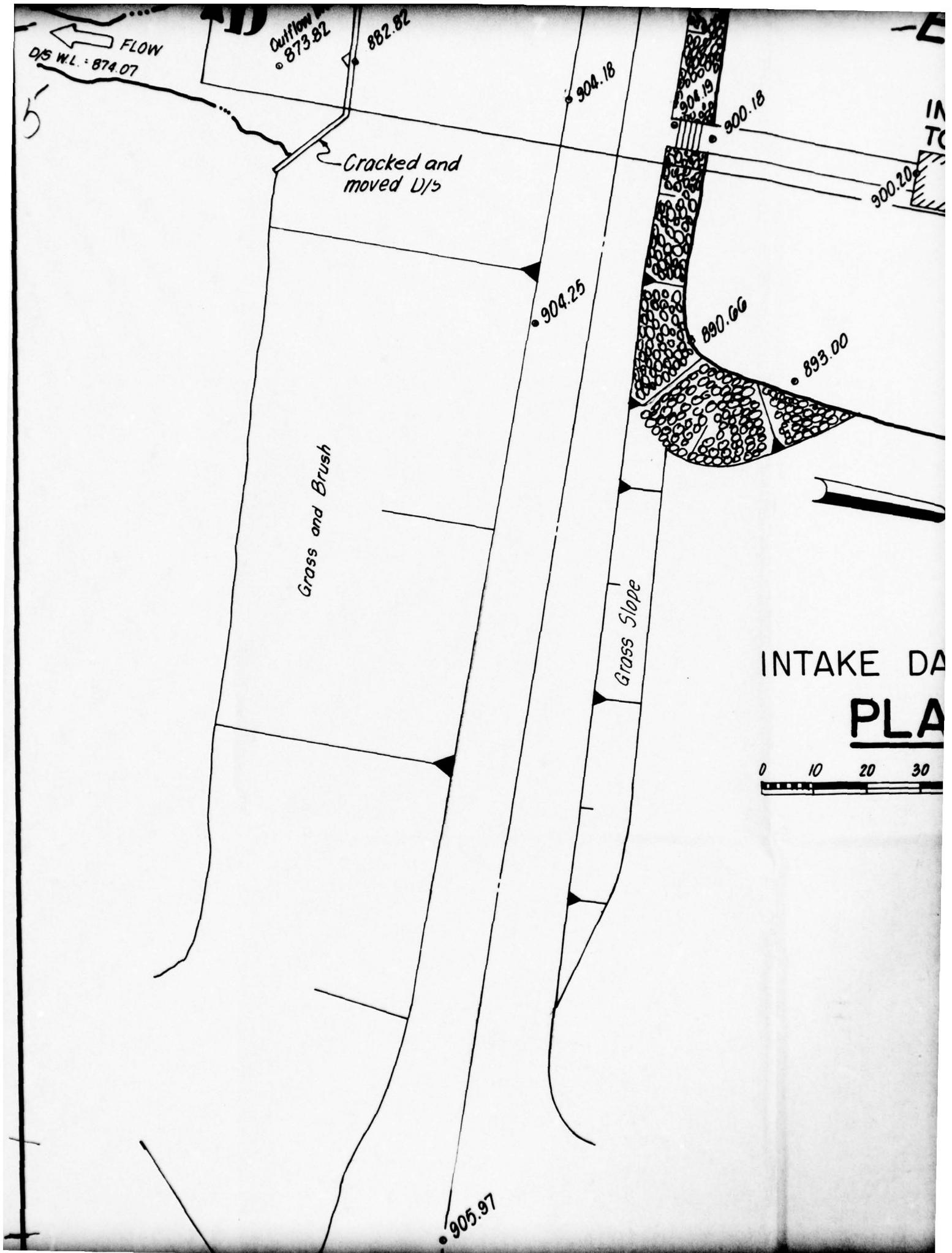
SPILLWAY-CROSS SECTION

SECTION A-A'

0 10 20 30 ft

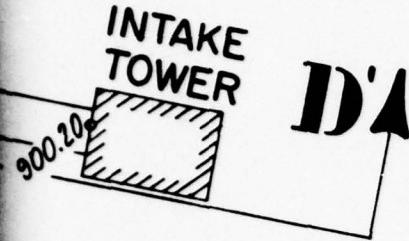
NOTE:

Elevations and general details obtained from Site inspection, USGS Maps, Optical Survey with Transit and rod, and drawings provided by NJDEP.



6

ECHO LAKE



DAM AREA PLAN

30 40 50 60 ft

67' TO CONCRETE BOX
CULVERT BELOW ECHO LAKE RD.
10' WIDE, 7'HIGH, AND
86' LONG.

DISCHARGE CHANNEL

ROCK

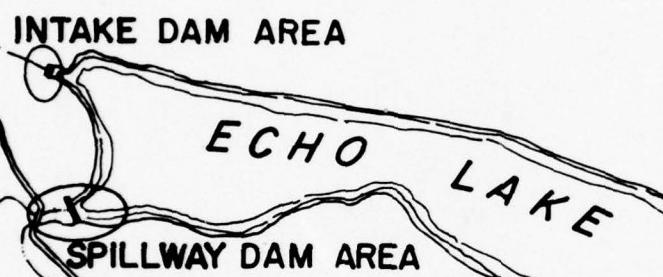
STONE ARCH UN
9.9' WIDE, 8.8'
AND 30.2' LONG

.903.38

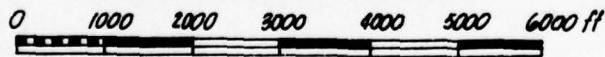
.984.66

BORING LOGS / CROSS SECTIONS

SECTION C-C'



KEY MAP



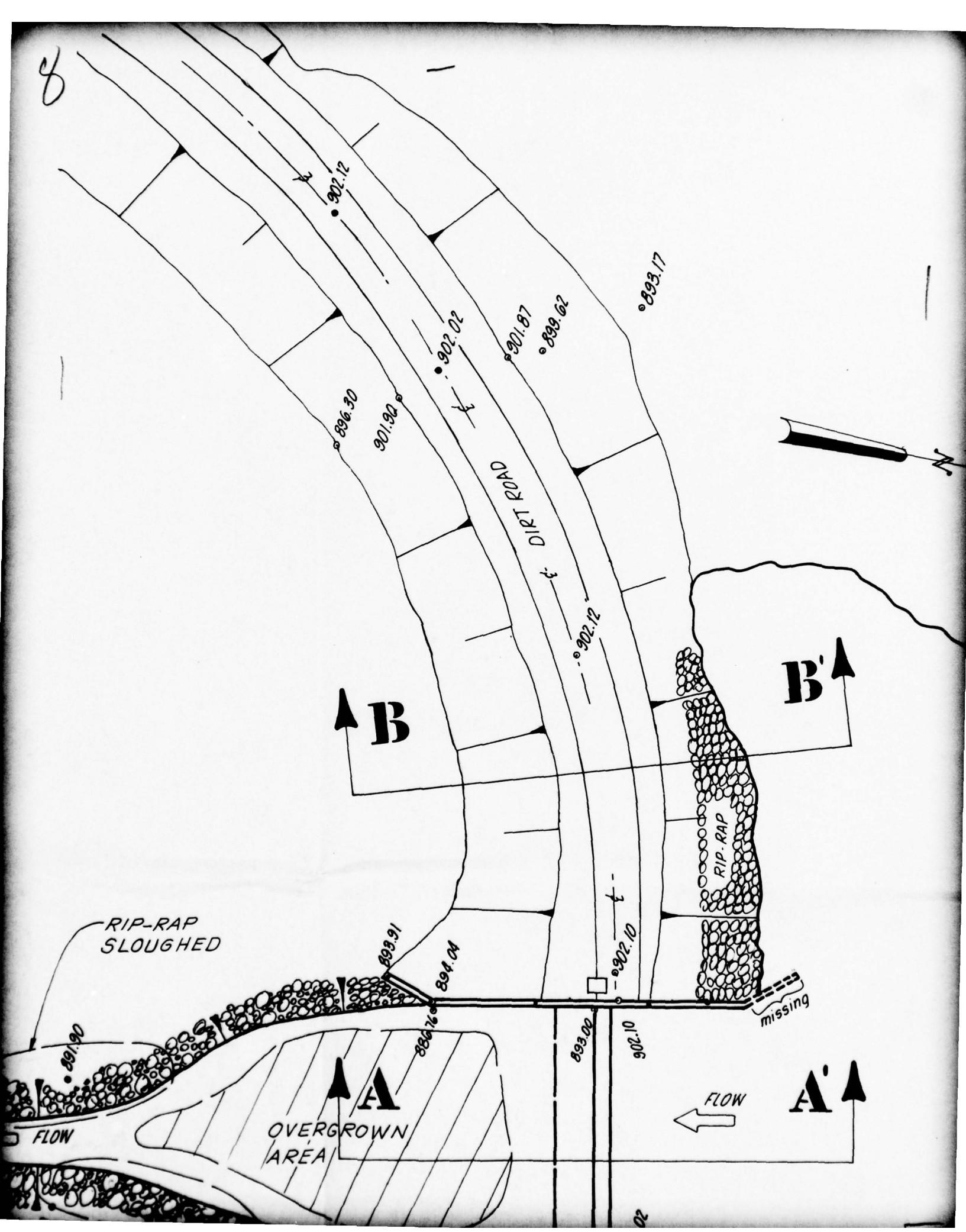
ARCH UNDERPASS
IDE, 8.8' HIGH,
0.2' LONG.

C

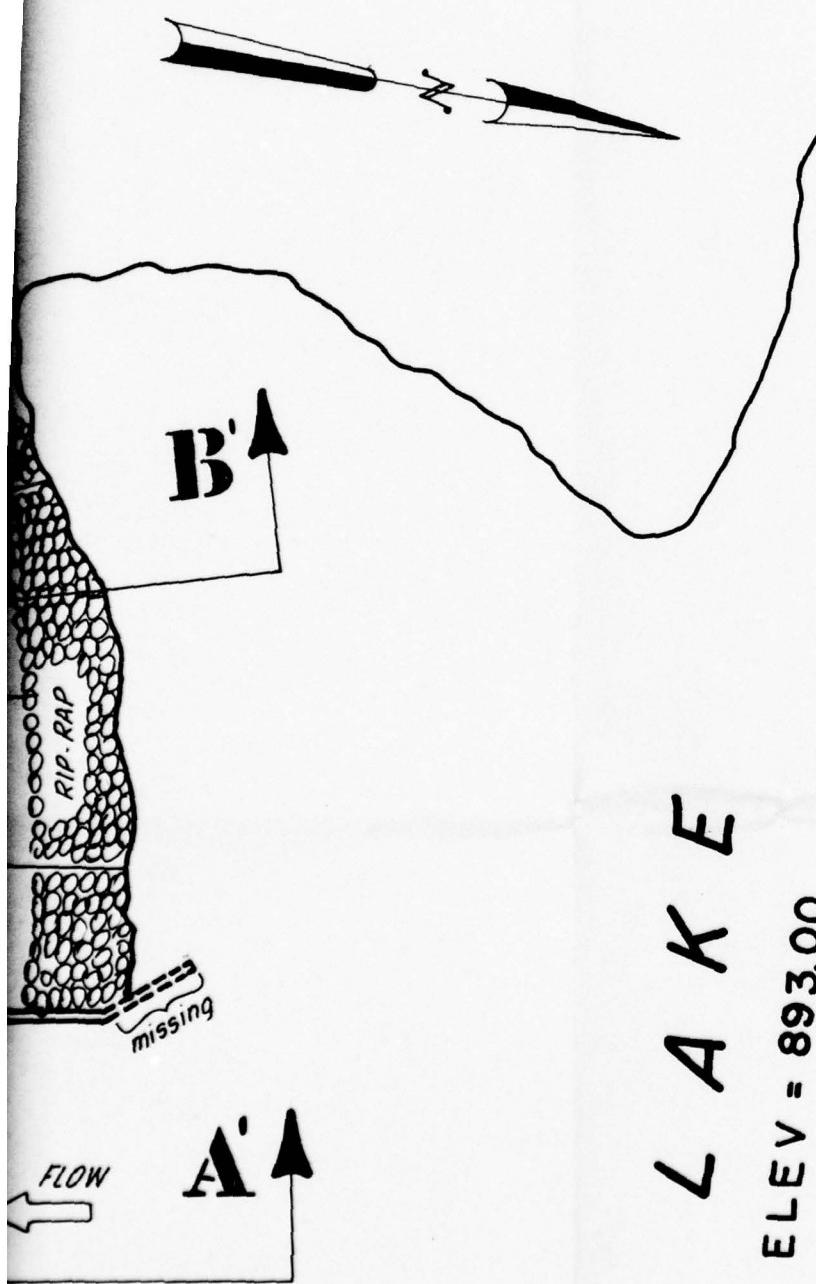
RIP-RAP

SPILLWAY CHANNEL

FLOW

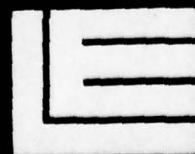
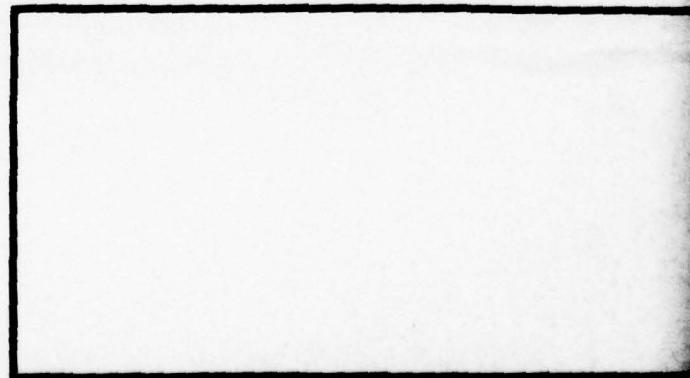


9



O L A K E
LEVEL ELEV = 893.00

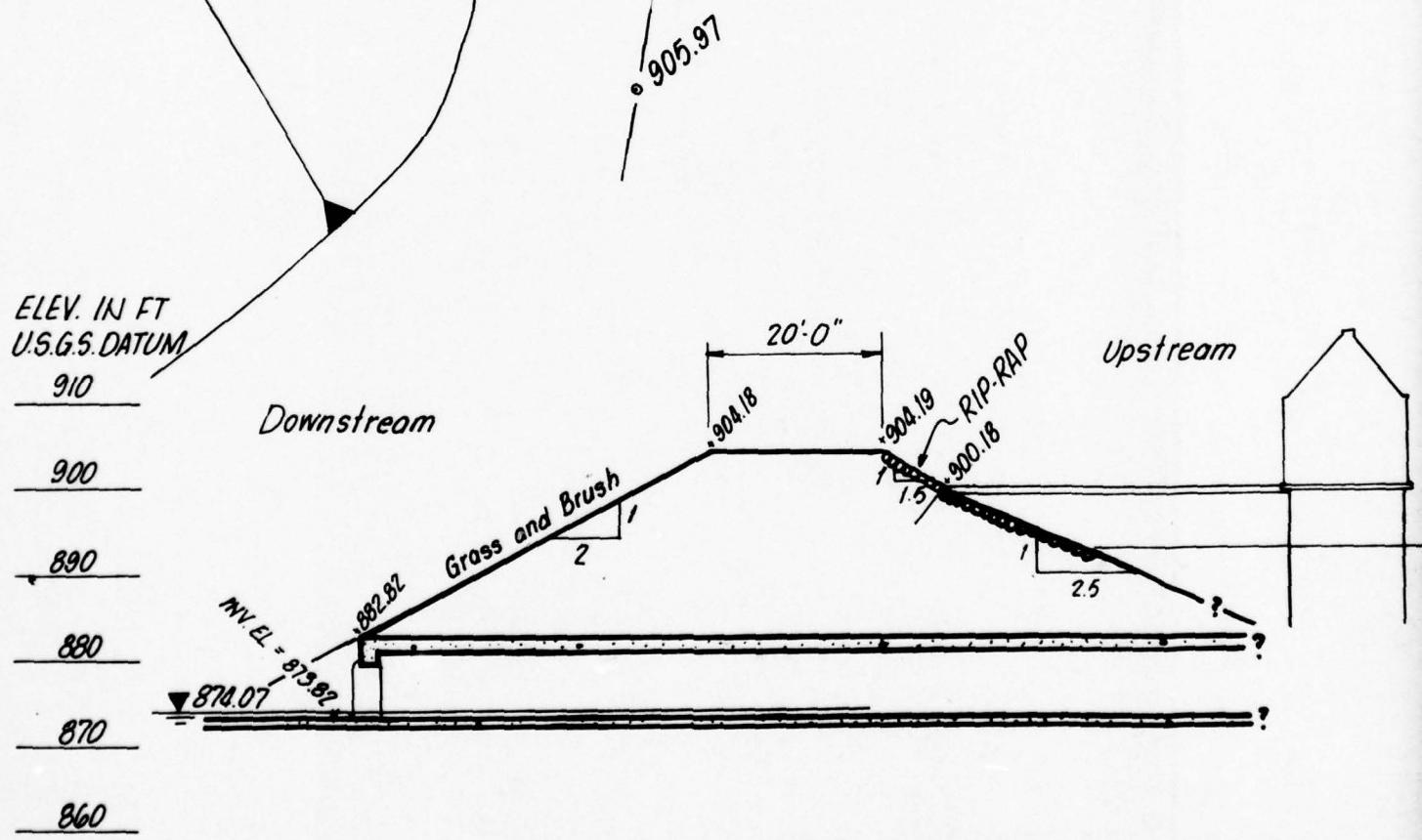
DATE	DESCRIPTION	NO
REVISIONS		



CANIGAN FLOOD PLAIN DRAINAGE DISTRICT

PLA

0 10 20 30



INTAKE DAM-CROSS SECTION

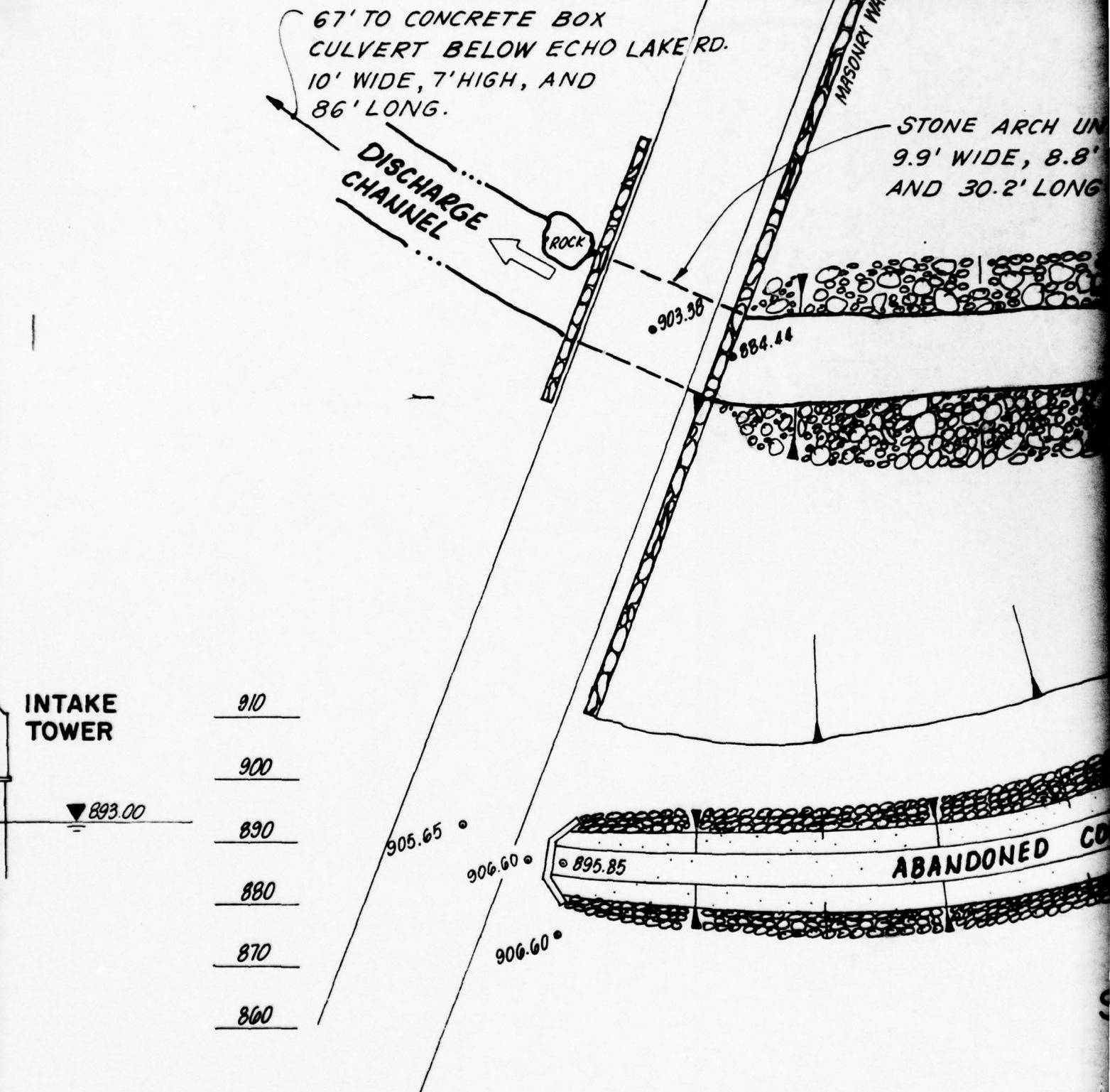
SECTION D-D'

0 10 20 30 40 50 60 ft

DAM AREA

PLAN

30 40 50 60 ft



KEY MAP

0 1000 2000 3000 4000 5000 6000 ft

UNDERPASS
8.8' HIGH,
ONG.



RI
SL

RIP-RAP

SPILLWAY CHANNEL

891.90

891.98

RI
SL

895.98

897.92

894.24

901.58

CONCRETE CHANNEL FOR COTTERS BROOK DIVERSION INTO ECHO LAKE



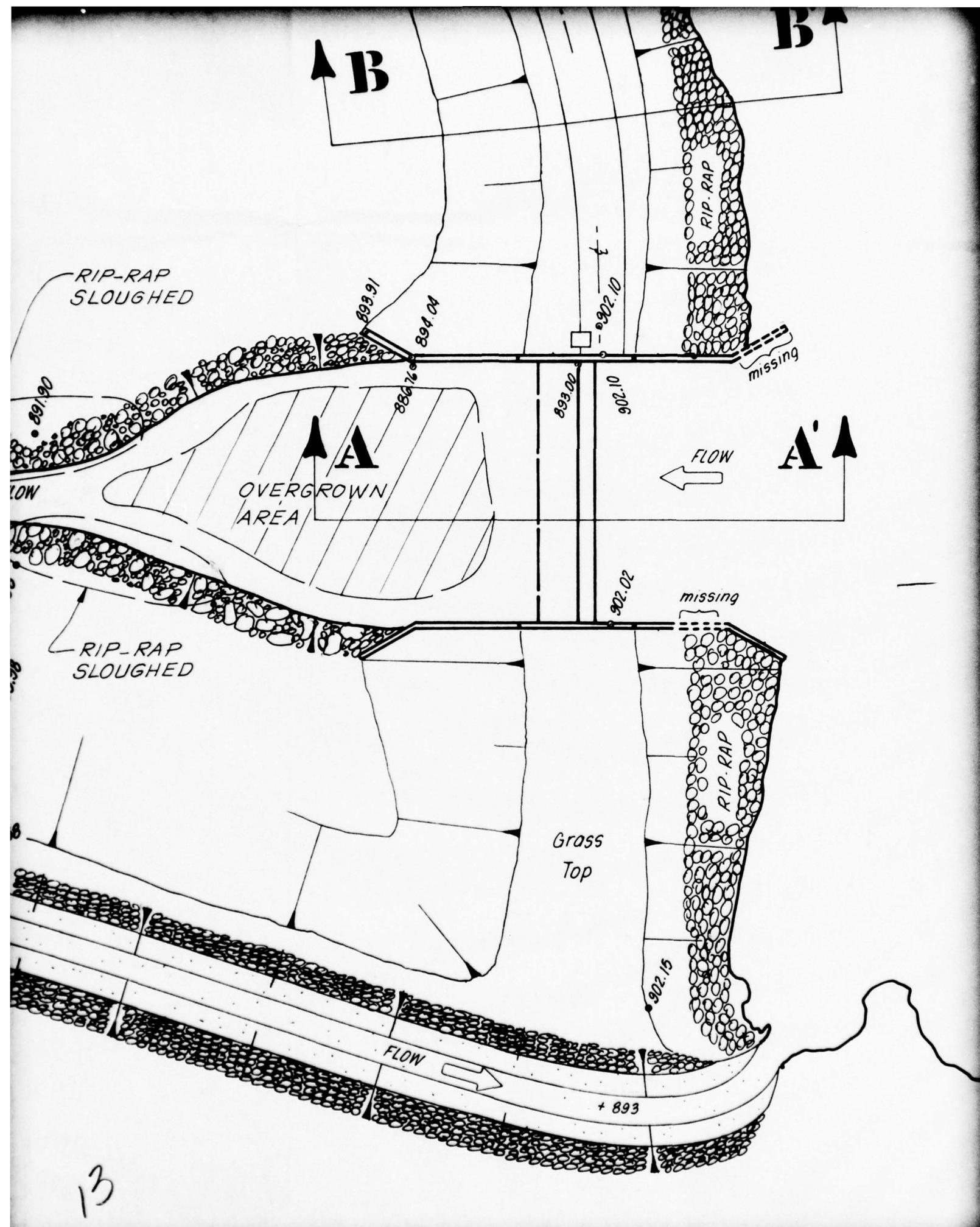
RIP-RAP

SPILLWAY DAM & DIVERSION CHANNEL AREA

PLAN

0 10 20 30 40 50 60 ft

12



DATE

DESCRIPTION

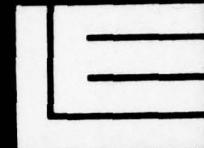
NO.

REVISIONS

A' ↑

ECHO LAKE

WATER LEVEL ELEV = 893.00



LANGAN ENGINEERING ASSOCIATES, INC.

970 Clifton Avenue, Clifton, New Jersey 07013
 (201) 472-9366

PROJECT

PHASE I
INSPECTION & EVALUATION
 of
NEW JERSEY DAMS

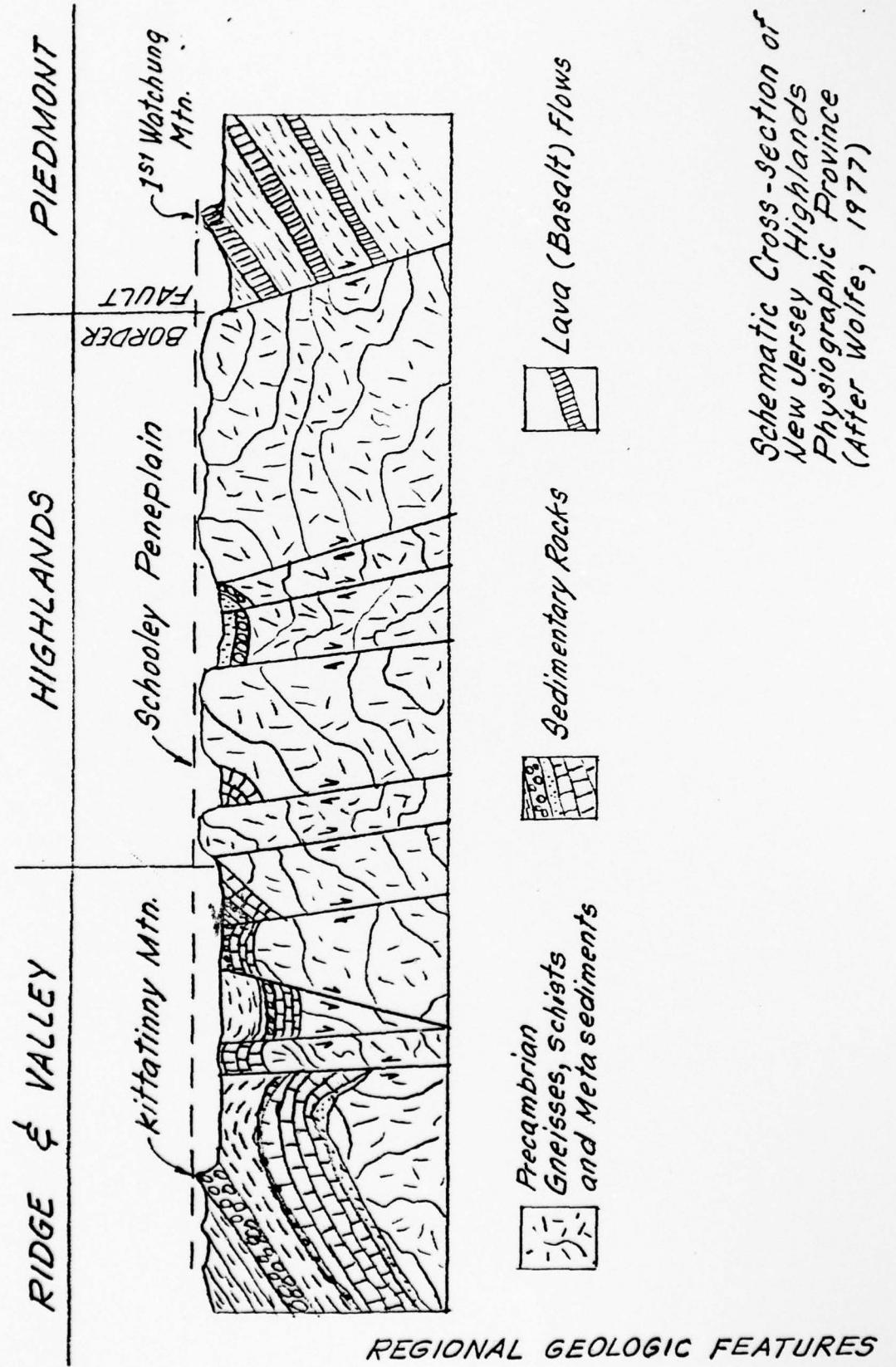
ECHO LAKE DAMS

JUNE 1978

INTAKE DAM FED. I.D. No. N.J. 00315
SPILLWAY DAM FED. I.D. No. N.J. 00558

JOB NO.	J 783
DATE	5 July 1978
SCALE	as noted
DRN. BY	JMR
CHKD. BY	DJL

FIG. 2



Schematic Cross-section of
New Jersey High/lands
Physiographic Province
(After Wolfe, 1977)

Fig 3

APPENDIX 1

CHECK LIST

VISUAL INSPECTION

ECHO LAKE DAMS

ECHO LAKE DAMS
Check List
Visual Inspection
Phase 1

Name Dam Echo Lake Dam County Passaic State New Jersey Coordinators NJ DEP _____

Date(s) Inspection 13, 14, 20, Weather Sunny Temperature 70 - 80° F
26, June 1978

Pool Elevation at Time of Inspection 893 M.S.L. Tailwater at Time of Inspection 875 M.S.L.

Inspection Personnel:

A. Puyo _____ G. Bondy _____
D. Leary _____ D. Lachel _____
D. Leary _____

Owner Personnel Present:

Mr. Frank Yacovone _____
Mr. John Deering _____
Mr. Earl Herb _____

D. Leary _____ Recorder _____

ECHO LAKE DAMS
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed	
SLoughing or Erosion of Embankment and Abutment Slopes	None Observed	
Vertical and Horizontal Alignment of Tie Crest	Good	
RIPRAP FAILURES	Associated with upstream side walls of spillway cracks and wall failure.	Should be repaired when side walls of spillway are repaired.

ECHO LAKE DAMS
EMBANKMENT

Sheet 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ADEUTMENT, SPILLWAY AND DAM	Walls of spillway have failed at upstream junction with embankment.	Requires repair.
ANY NOTICEABLE SEEPAGE	None Observed.	
STAFF GAGE AND RECORDER	Staff gage in good condition.	
DRAINS	No drains observed.	

ECHO LAKE DAMS

VISUAL EXAMINATION OF	OUTLET WORKS	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT		None	
INTAKE STRUCTURE		Appeared in good condition	
OUTLET STRUCTURE		Appears in Good Condition except outlet retaining walls have cracked and moved downstream.	Retaining walls should be repaired.
OUTLET CHANNEL		May have two to three feet of silt.	
EMERGENCY GATE			Outlet gates can be used in emergency to lower lake level.

ECHO LAKE DAMS

UNGATED SPILLWAY		
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Good. Minor spalling near vertical grooves in face of concrete at possible construction joints.	
APPROACH CHANNEL	Good except for sidewall failures. Failure has occurred at both upstream sidewalls.	Sidewalls should be repaired.
DISCHARGE CHANNEL	Good except for obstruction by boulder at end of roadway underpass.	Boulder should be removed.
BRIDGE AND PIERS	None. Crest of spillway clear except for flashboard pins.	

ECHO LAKE DAM

INSTRUMENTATION		
VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed or reported in available data.	
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTIER		

ECHO LAKE DAMS

VISUAL EXAMINATION OF	RESERVOIR	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES		Good. No signs of slope instability. Slopes range from about 5 hor to 1 vert to 15 hor to 1 vert.	
SEDIMENTATION			Likely there has been relatively little sedimentation.

ECHO LAKE DAMS

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

OBSERVATIONS

Flashboard pins could cause
obstruction at crest of spillway
and boulder at roadway underpass.

REMARKS OR RECOMMENDATIONS

Possible obstruction of
the tunnel below the
road by debris.

SLOPES

Good Condition

APPROXIMATE NO.
OF HOMES AND
POPULATION

Butler is reported to be nearest
City with population of 7,051.

ECHO LAKE DAMS
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

<u>ITEM</u>	<u>REMARKS</u>
PLAN OF DAM	Good but details difficult to read.
REGIONAL VICINITY MAP	Good
CONSTRUCTION HISTORY	Good with respect to chronology.
TYPICAL SECTIONS OF DAM	Typical section of Intake dams embankment at intake tower and conduit through embankment are missing. Daily water level records.
HYDROLOGIC/HYDRAULIC DATA	
OUTLETS - PLAN	
- DETAILS	
-CONSTRAINTS	
-DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS	None

ECHO LAKE DAMS

ITEM	REMARKS
DESIGN REPORTS	Fair
GEOLOGY REPORTS	Poor
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Poor
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	NONE

ECHO LAKE DAMS

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Poor Condition
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Poor Condition

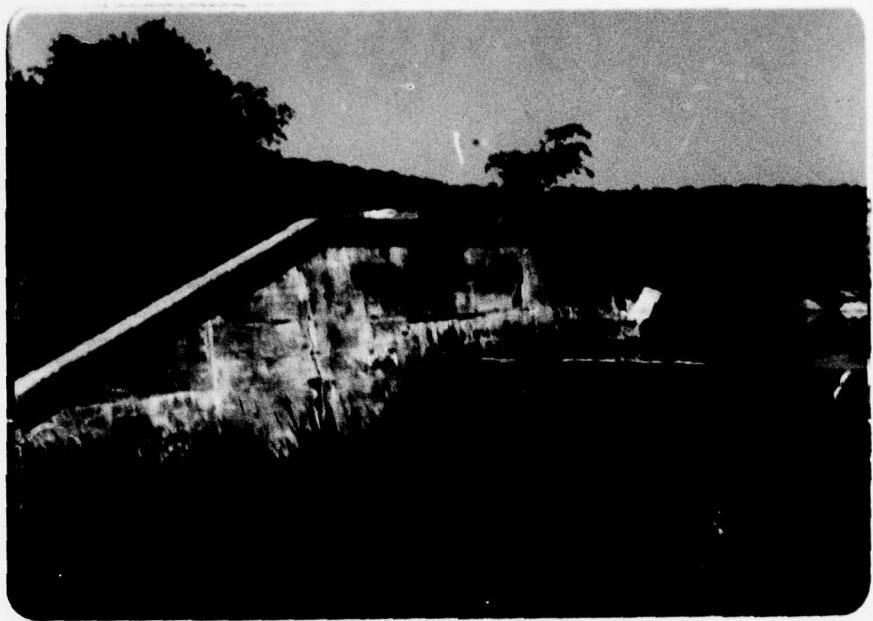
ECHO LAKE DAMS

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	None except those made during construction.
HIGH POOL RECORDS	October, 1903 at el 898 prior to Construction of existing dam.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None except dam inspection report at conclusion of construction.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	Daily water level records.

APPENDIX 2

PHOTOGRAPHS

ECHO LAKE DAMS



Right side-wall of
spillway.

20 June 1978



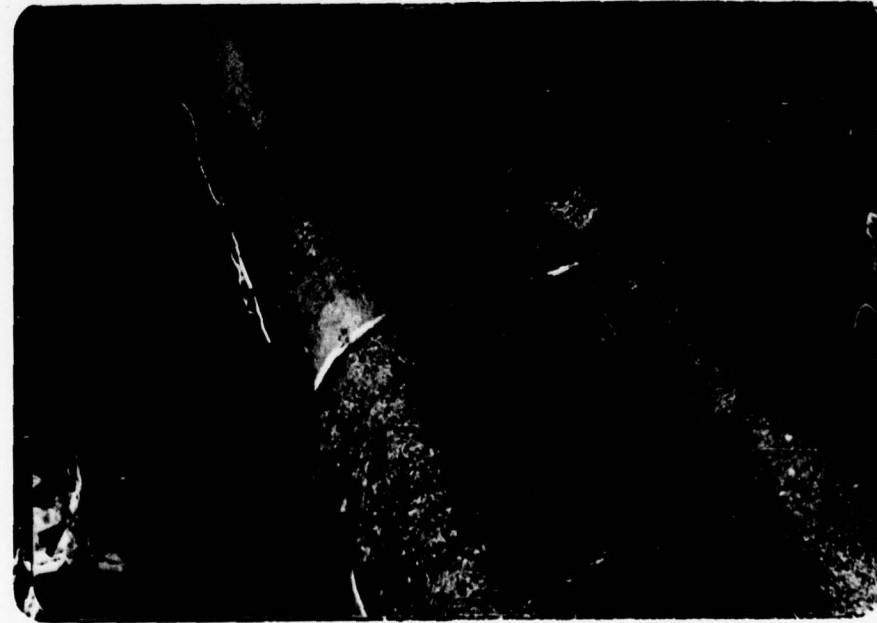
Low level outlet at right side
wall of spillway.

20 June 1978

ECHO LAKE DAM



TOP OF SPILLWAY. Note debris behind flash board pins.



FACE OF SPILLWAY. Note deterioration of concrete at construction joint.

ECHO LAKE DAM



Spillway discharge canal
looking upstream.

20 June 1978



Culverts below road and Route 23
along spillway discharge canal looking
downstream. Note boulder at end of culvert
below road.

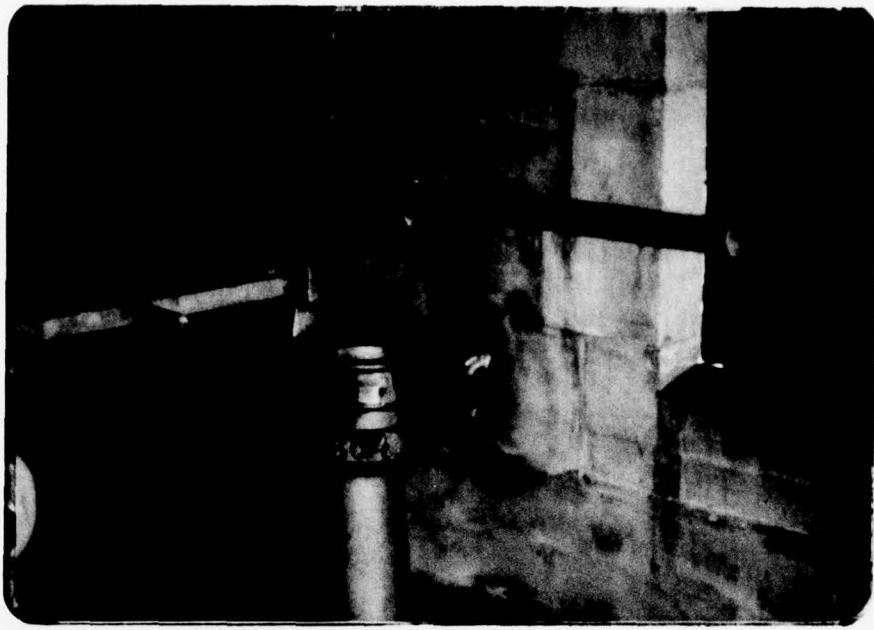
ECHO LAKE DAM



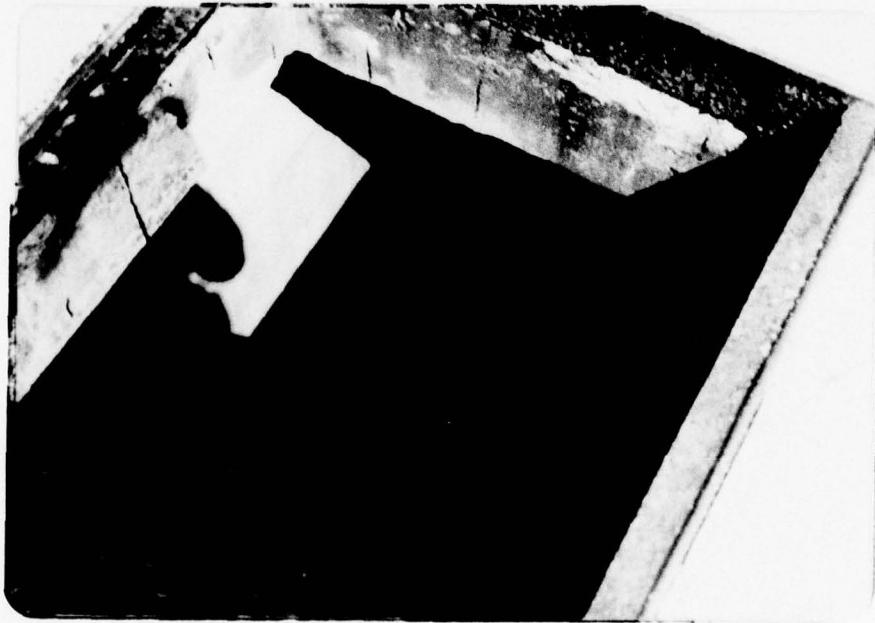
Upstream riprap at right embankment looking west from spillway. 20 June 1978



Upstream rip rap at right embankment. Looking west from intake structure. 20 June 1978



One of three Rodney Hunt manually operated control valves at intake structure. 20 June 1978



Control valve at right side of spillway. 20 June 1978

ECHO LAKE DAM



Right wing wall of intake structure discharge tunnel. 20 June 1978



Left wing wall of intake structure discharge tunnel. 20 June 1978

ECHO LAKE DAM

APPENDIX 3

ENGINEERING AND CONSTRUCTION DATA

ECHO LAKE DAMS

14 MARCH 1926

Report of Hydraulic Engineer
Echo Lake Improvement
Division of Water

Mr. James W. Costello, Chief Engineer,
Department of Public Affairs,
Newark, N.J.

Dear Sir:

Herewith is submitted a report of the development of Echo Lake to secure additional water supply from the Pequannock watershed.

An hydraulic engineer experienced in the design and construction of earth dams was employed and the work of investigation, design and preparation of plans looking to the improvement and increased supply of water from Echo Lake, actively taken up on April 1, 1925.

Specifications for test borings were prepared at once and bids secured from four firms as follows:

Bidder	Price per foot	Price per day	Number units	Type equipment	Core diam.
1. Phillips & Worthington, New York	\$4.00	\$40.00	2	Shot	1 1/4" to 1 3/4"
2. Watson G. Clark, New York	5.25	52.00*	2	Shot	2"
3. Osborne Drilling Corp., New York	6.00	.35.00#	2	Diamond 15/16"	
4. Giles Drilling Co. Inc., New York	7.00	41.00		Diamond 7/8"	

*\$45.00 per day without superintendent
#Plus \$90.00 per karat of diamond loss

The contract was awarded to Phillips & Worthington of New York on April 18, 1925. Work began on April 22 and was completed August 5, 1925. Under this contract 51 borings were made on a damsite near the existing outlet and along the diversion and outlet channels and on two damsites at the south west corner of the lake. A total of 1279.14 lineal feet of drilling was done as follows: 42 holes on land amounting to 1135.84 feet at \$4.00 per foot, costing \$4554.53 and five holes amounting to

140.50 lineal feet in the lake bottom, made from a float, paid the per day price of \$40.00, or \$5.39 per foot, costing \$751.50, a total of \$2354.56. Test pits were dug on the site of borrow pits and mechanical analyses made of the materials to determine their suitability for use in earth dam construction.

Surveys were begun April 14 with a non-engineering assistant and two laborers. The assistant was replaced by an engineering graduate on May 18. Three temporary assistants were employed during a part of June, July and August. A second engineering assistant, capable of doing drafting, was added to the force on Dec. 15.

Topographic surveys covering 50 acres were made of the area that will be affected by construction operations at the foot of the lake, and a survey of the proposed new 7,500 foot outlet channel. A survey was also made of the Macopin Branch Railroad leading from the main line of the New York, Susquehanna & Western (Erie) Railroad to Echo Lake, length of survey 1.64 miles.

The major field operation was the determination of the area and volume of the lake. A triangulation survey of the lake was made and with this as a basis, soundings below and elevations above the water surface were determined along the entire lake shore a distance of 5.6 miles. The soundings were supplemented by work done by Mr. Bankman 1922. The area covered by this survey is 340 acres. In addition, 1.5 miles of location lines were run in Hammock swamp. From the map based on this survey were determined the area and capacity of the lake at two foot intervals from the bottom to elevation 896 of four feet above the present full lake surface and from the volumes and areas were obtained the amount of storage and the amount available for use. A mass curve or diagram was made showing the total amount of water in a million gallons that has run off the combined drainage areas of Echo Lake and its tributary, Cotters Brook, in the past 32 years. From these data were determined the proportions of the dams, spillway, outlet works and channels. The above mentioned field work and the plotting of maps was continuous throughout the Summer and Fall. All field work and maps were completed early in December.

In addition to the above, several reports and estimates of cost were made during the summer. Tentative designs and complete estimates were made of five projects including seven dams. The first of these estimates was prepared during August and submitted August 31st. Other estimates were later requested and submitted on October 12th. On that date one of the projects was accepted and directions given to proceed with the final design and plans.

The surveys and studies for increasing the storage in Echo Lake were begun with a view to raising the lake surface about eight feet or to a height that the yield of the watershed showed to be economical. It was realized at the beginning of the investigation that it would be very undesirable to flood the great swamp at the head of the lake, Hammock Swamp, and thus produce a large shallow area to evaporation and aquatic growth and at the same time increase instead of diminish the color and microscopic organisms.

The basin of the lake has steep, rocky underwater shores and a maximum depth of over thirty feet. More than 68% of its area has a depth of twenty feet with 80% of its volume above the twenty foot depth. At an early stage of the investigation effort was directed toward finding a solution of the problem by drawing from the present elevation rather than by raising it, and thus secure the increased supply from the existing clean and deep reservoir.

Echo Lake and the Pequannock watershed lie within the glaciated area of Northern New Jersey. The lake basin was formed by the obstruction of a river valley by means of glacial drift. The drift at the south or outlet end of the lake takes the form of a hardpan overlaying bedrock. Test borings show bedrock to be at no great distance, seven to thirty feet, below the ground surface except near the center of the valley where a driven well discloses rock at a depth of 120 feet. The valley is 2,000 feet wide in the vicinity of the south end of the lake. The lake has two outlets, that in the south west corner, perhaps the original outlet, being now obstructed by the embankment of the Macopin Branch Railroad. The westerly outlet, about 7,500 feet long, enters the Pequannock just below the New York, Susquehanna & Western Railroad bridge and above the Macopin Intake. The easterly outlet enters the channel of Cotter's Brook and reaches the river at the head of the Macopin Intake pond, a distance of about 10,500 feet from the lake. The regulated elevation of the lake, weir crest, is 892 feet above the mean sea level.

The drawdown permitted by the outlet channel is 5.0 feet and the available storage 425 million gallons. The watershed of Echo Lake including water surface, has an area of 2.41 square miles.

Cotter's Brook watershed has an area of 1.94 square miles.

The borings disclosed the fact that the easterly or present outlet channel was excavated nearly to bedrock, and that deepening would require extensive rock excavation, while a channel at the westerly outlet would be in earth with a minimum of rock to be removed. The project accepted and now being worked out in detail, calls for a 50 foot concrete spillway at the present easterly outlet with its crest elevation at 893 or one foot above the present lake elevation. The spillway dam will be an earth structure with its crest at elevation 902, or nine feet above the spillway crest, allowing the use of three feet of flash boards and a flood depth of two feet. A portion of the Cotter's Brook diversion channel will be paved to prevent seepage losses and a larger culvert built to pass higher flows into the lake.

The outlet channel, dam and control works will be located at the south west corner of the lake. The bottom of the outlet channel at the dam will be at elevation 872 and have a length of 1,870 feet. The discharge will be into an existing stream. A portion of this stream is located on railroad property and will be improved to protect the fills from erosion by the increased amount of water carried. The bottom of the approach channel will be level and extend 1,670 feet into the lake to contour 870. The outlet dam will be an earth structure with its crest at

elevation 904 and having a height of 32 feet above the outlet channel. A reinforced concrete conduit will carry the water through the dam. Water will enter the conduit through an intake tower in which the gates will be placed at different elevations, permitting drawing at whatever depth examination and analysis shows the water to be of better quality. The water slopes of the dam will be paved and their tops and downstream slopes grassed. Service roads will be provided at both of the dams. The excavation for and construction of the outlet dam, conduit, intake tower and major portion of the outlet channel will be done behind a coffer-dam built across the cove in the south west corner of the lake. This will be a pile and timber structure supporting a single line of steel sheet piling. After completion of the dam and other structures, the steel sheet piling dam will be retained as a barrier to hold back drifting ice and debris from the approach channel and intake tower.

In addition to less cost of construction attained by placing the outlet structures and channel at the south west corner of the lake, thereby avoiding excessive rock excavation, another advantage is gained by being able to discharge large flows from Echo Lake into the upper end of a future reservoir at Charlestown and thence into a new conduit leading to the City. Still another advantage is that the entrance of Cotter's Brook into the lake will be some 2,000 feet from the outlet, allowing more time for storage and bleaching than is permitted now with the entrance directly at the outlet. Also the drawing down of the lake to lower levels and for longer periods will permit better and more rapid drainage of Hammock Swamp and make future ditching more economical and effective.

The proposed outlet channel is designed to carry 93 second feet or 60 million gallons daily, the full capacity of the existing pipe line to the City, with the idea that Echo Lake, being near the intake, may be drawn upon to nearly this amount for quick delivery in case other sources of supply are temporarily unavailable. For future delivery to a reservoir at Charlestown a channel capacity of 300 second feet will be provided.

This capacity would have taken care of all but eight storms in the past 27 years, with a full lake, water would have wasted over the spillway an average of once in 3.4 years. The 93 second feet or 60 million gallons daily, will flow along the Macopin Branch railroad right-of-way in the channel of an existing stream which leaves the right-of-way about 3,600 feet from the dam. The larger quantity of 300 second feet will continue along the right-of-way to the reservoir. When this takes place, additional construction will be required on embankments and under the State Highway and main line of the Susquehanna railroad.

In providing for these large flows and for taking water from the lake at different elevations, large gates will be employed. Having more than one of these gates open at the same time, either by mistake or maliciously, would cause dangerously high flows in the channels. To coviate this an interlocking device will be

installed which will prevent more than one gate being open at a time. Another safety measure will be the building of the outlet or westerly dam two feet higher than the spillway or easterly dam. During the flood of October 1903, the lake rose to about elevation 898 and water flowed down the valley in which the outlet dam will be located. This height of water was probably due in part to blocking by driftwood of the large culvert under the highway just below the present outlet. A section of the road over this culvert is at elevation 903, and the crest of the diversion dam on Cotter's Brook is at the same elevation. Water could flow over the road for a time without serious damage but not over the outlet dam. To prevent this the crest of the outlet dam will be at elevation 904.

The amount of available water that can be stored in the lake between elevations 872 and 893, a depth of 21 feet or the amount of the drawdown made possible by the outlet channel, will be 1,586 million gallons or a supply of 4.35 million gallons per day.

This is an increase of 1,163 million gallons of available water.

The assumed runoff from the drainage area is at the rate of 1.1 million gallons per day per square mile. The area of the watershed tributary to the lake is 4.35 square miles. With care in maintaining the height of water in the lake and allowing no waste over the spillway, a rate of 4.8 million gallons per day may be obtained. Storage to elevation 893 in the lake gives a development of 91% or stores 91% of the annual runoff of the watershed.

The area of the lake at elevation 893 will be 282 acres. The maximum discharge at Macopin Intake during the flood of 1903 appears to have been at the rate of 16 second feet per square mile from the Pequannock drainage area of 63.7 square miles. This rate adjusted to the smaller area of the Echo Lake watershed was used for the maximum flood flows, the rate used being 153 second feet per square mile.

The work of clearing damsites, channel locations and the shores of the lake to contour 896 was begun on October 22, 1925. This work is being done by City forces under the direction of Superintendent Reilly and under the inspection of the engineers. Six miles of cutting lines have been marked by the engineers. One hundred oak piles for the cofferdam, 20 to 30 feet long, are being furnished from the clearing operations in addition to cord wood and saw logs sold. The area to be cleared amounts to 40 acres. At the end of the year 11% of this area had been cut over.

Negotiations were begun in July for the purchase of the Macopin Branch Railroad from the Erie Railroad Company. This branch railroad formerly served the ice industry at Echo Lake and is of no further use and the Railroad Company has voted to abandon it.

This action awaits the approval of the Interstate Commerce Commission and the State authorities of Pennsylvania.

On December 31st the design and plans of the lake improvement project were well under way and their completion and the preparation of contracts and specifications assured by the beginning of the construction season in April.

Abstract From Construction Specifications - Echo Lake Dam

Sect. 10.2. Preparation of Base for Embankments. Embankments shall, in general, start from a firm base from which top-soil, timber, trees and roots and other perishable matter shall have been removed to the extent required. Loose stones, boulders and debris shall be removed from embankment sites to the extent directed. The base under embankments shall be ploughed just previous to placing embankments to make a bond with the embankment material, and on sloping ground shall be stepped where and as directed. This work shall not be measured under Items 1 or 2 except within the areas where specifically so indicated on the drawings. Where springs are encountered within the area to be covered by the dam they shall be cared for as shall be directed by the Engineer. In general springs within the downstream third of that area will be covered with rock and a blind drain of rock, laid on the natural surface, provided to the lower toe of the dam. Elsewhere the flow of the springs will be checked by the earth fill as it rises, care being taken to always force the flow upward instead of allowing it to form a watercourse through the completed fill. No permanent or temporary fill or structure will be allowed to be placed or built on any portion of the dam before that portion is thoroughly cleared and prepared as hereinbefore specified.

Sect. 10.3. Embankment Materials and Methods in General. Fill and embankments shall be made of acceptable materials from the excavations or from borrow pits. As far as is known very little acceptable material for Item 10, embankment, can be obtained from the excavations. It is expected that these materials will be obtained from borrow pits located as shown on the drawings. Before excavating embankment materials, all grass, weeds, crops, and surface roots shall be acceptably removed by mowing, burning, plowing well in advance of time of excavation, harrowing if ordered, or other approved methods. Fill and embankment materials shall be substantially free from perishable matter and from materials liable to become unsuitable when saturated with water after having been compacted. Any places that become boggy or springy shall be corrected to the satisfaction of the Engineer and such material as necessary shall be removed and the holes refilled in a satisfactory manner. Should the Engineer direct that unsuitable material be excavated and removed from the embankment the work shall be properly done by the Contractor at his expense and the space refilled and compacted as specified. All stones allowed to remain shall be separated from each other by fine earth. No stone having any dimension greater than 4 inches shall be used. Large c. earth over 6 inches in any dimension shall be broken up.

Sect. 10.4. Frozen Materials. No frozen material shall be used in the construction of the embankment of the dams, and no material shall be placed on portions of these embankments which are frozen.

Fill an embankment shall be compacted by ramming or rolling or both, or by other means as required, and wherever built against masonry, if directed, shall be carried up with the masonry at an acceptable distance below its top, maintaining the surface of the entire embankment so far as practicable at an approximately level surface.

Sect. 10.5. Allowance for Shrinkage. The embankments shall be built to a height above the finished grade which will, in the opinion of the Engineer, allow for the shrinkage of the material. If such ordered overfill results in an excess section of any embankment at the time of final acceptance of the work to be done under this contract, such excess shall be included in the measurements. If any embankment settles so as to be below the required levels for the proposed finished surface at any place, before the final acceptance of the work, the Contractor shall supply approved materials and build up the low places as directed.

Sect. 10.6. Classifications of Fill and Embankment. Fill and embankment shall be classified for payment according to its physical characteristics and special requirements as follows:

Item 10 shall include fill consisting of acceptable earth, sand, or gravel. It shall be placed on the east side of the spillway channel and as a cover over the area marked "Tin Bump" and in the larger coffer-dam as shown on the drawings and elsewhere as ordered, or indicated in the drawings.

Item 11 shall include impervious fill and embankment consisting of selected, acceptable earth containing enough clay, soil, or other fine material to compact and form a water-tight embankment and deposited in layers not exceeding 6 inches in thickness when spread as required. Item 11 shall include the impervious fill in cut-off trenches and embankment required for the outlet and spillway dams and for the embankment along the diversion channel within the limits shown on the drawings or ordered and elsewhere if directed.

Sect. 10.7. Consolidating Impervious Fill and Embankment. Earth for impervious fill and embankment, Item 11, shall unless otherwise specially ordered or permitted, as prescribed in Sect. 10.3 be spread in approximately horizontal layers longitudinally and sloping slightly toward the center transversely and extending over the entire surface of the embankment, and not more than 6 inches in thickness when spread.

Motor drawn dump wagons or other vehicles approved by the Engineer, shall be used for transporting the material for the refill and embankments, and shall be routed so as to produce the greatest amount of compacting of the material in the areas.

The spreading shall be done by heavy road spreaders, hauled by caterpillar tractors or tractors having blade wheels or by motor driven bulldozers.

The fills and embankments shall be consolidated by the use of rollers and water to the extent that the voids in the material shall be reduced to not more than 33 per cent of the volume of the compacted earth as determined by samples taken from the fills and embankments under construction.

It is assumed that the degree of compactness required can be brought about by the use of rollers and water.

Approved power rollers with grooved or tandem rolls shall be used. The rear wheel or wheels of the roller shall be of such width and diameter and shall bear such a proportion of the total weight of the roller that with a penetration of 1 inch it shall cause a calculate average pressure on the tank of at least 30 pounds to the square inch on its entire bearing surface. The bearing surface considered shall be the width of the roll multiplied by half the arc bounding a segment of the roller at the bottom of the grooves, having a middle or width of

Pipe lines with nozzles connections not less than 100 feet apart shall be laid along the damsite for supplying water.

A capacity of not less than 50 gallons per minute at the nozzle shall be provided for each of not less than two nozzles.

The number of nozzles of this capacity shall be increased if required.

The surface to be covered by a load of earth shall be thoroughly wet just previous to dumping the load. This procedure shall be rigidly adhered to; the object being to get and retain the proper amount of water within the earth mass and to avoid the formation of pools and muddy, slippery surfaces.

Rolling and wetting shall be continued until the required compactness is obtained. If these methods are not sufficient, the weight of rollers and amount of water shall be increased.

Sect. 10.8. Special Compacting. Portions of the fill and embankment which are very small in area, those portions adjoining the cut-off walls, other portions which the rollers cannot reach for any reason and material used for refilling trenches, if so ordered, shall be compacted by means of mechanical tampers operated by compressed air or otherwise, or by extra heavy hand tampers used energetically, or by depositing the earth by or through water in such manner that all of it shall be thoroughly saturated but not stratified, or by other means which will secure a satisfactory degree of compacting.

Sect. 10G.1. Kinds of Masonry and Where Used. Concrete masonry will be required in the spillway and walls, the cut-off walls, and for paving the diversion channel, and elsewhere as shown on the drawings or ordered. Reinforced concrete will be used in the outlet conduit, the intake tower, and in two culverts, and elsewhere as shown on the drawings or ordered. Stone or brick masonry will be used to face the gate house walls. Paving laid dry will be used for the slope paving on the upstream side of the earth dam, for the overflow channel, and portions of the diversion and outlet channels and elsewhere as shown on the drawings or ordered.

Sect. 10G.2. Preparing the Foundations for Masonry. Before laying masonry of any class at a given place the rock or other foundation, or the masonry previously laid, shall be properly prepared as herein specified or as directed, and when beginning to place the masonry a bed of fresh mortar of the quality hereinafter specified and of the thickness required shall be spread over the foundation and thoroughly worked into all depressions and crevices. This work shall not be included in the measurement for Item 9, unless specifically designated as special preparation for rock surface under that item. Foundations, in earth, of the retaining walls and the overflow weir of the spillway, the culverts, and elsewhere as ordered, shall be rolled or tamped as directed.

Sect. 10G.18. Water and Consistency. Water for concrete and mortar shall be clean and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substance. The Contractor shall provide suitable and approved means for controlling and accurately measuring the water. The quantity of water used shall be the minimum necessary to mix concrete

of a workability required by the Engineer. The consistency of the concrete at the form shall be such that the slump test as described in "Tentative Method of Test for Consistency of Portland Cement Concrete for Pavements or for Pavement Base", Serial Designation D138-23T of the American Society for Testing Materials shall be within the limits indicated in the following table unless otherwise permitted or ordered:

Type of Concrete	Maximum Slump in Inches	Minimum Slump in Inches
Reinforced and watertight concrete	6	3
Mass concrete	3	1
Lean concrete for filling	3	1

Sect. 13.1. Work Included. Concrete is classified by use. Item 13 consists mainly of reinforced watertight concrete in the conduit and intake tower, culverts, channel paving and steps, and elsewhere as shown on the drawings or as ordered. Item 14 consists mainly of mass concrete in gravity section retaining and wing walls, spillway weir, conduit head-walls, cut-off walls, and supporting structures for cast iron pipe, and elsewhere as shown on the drawings or ordered. Item 15 is a lean concrete and shall be used for filling and other similar purposes as shown on the drawings or ordered.

Sect. 13.2. Placing. The concrete shall be placed continuously so as not to impair the strength of the structure. Unless otherwise permitted or required, the reinforced concrete for each section of the conduit shall be placed in one continuous operation. All steel reinforcement shall be placed in the exact positions and with the spacing shown on the drawings or as ordered, and shall be so fastened in position as to prevent displacement while the concrete is being deposited. To secure a watertight structure for the reinforced concrete conduit and intake tower more than ordinary care in mixing and placing concrete is essential.

APPENDIX 4

HYDROLOGIC COMPUTATIONS

ECHO LAKE DAMS

HYDROLOGIC COMPUTATIONS
ECHO LAKE DAM

Location Morris County N.J. in the Passaic River Basin

Drainage Area 1744 acres or 2.73 sq mi

Lake Area 270 acres

Classification Size - Intermediate
Hazard - High

Spillway Design Flood PMF

Calculate PMF

1. Echo Lake Dam is located in Zone G

PMP = 22.5 inches (200 sq mi 24 hr)

2. PMP Adjustment Factors

Duration (hr.)	% 24 hr	Reduction Factor *
0-6	112	
0-12	123	
0-24	132	.8 all hrs
0-48	142	

* p 48 "Small Dams"

DETERMINE TIME OF CONCENTRATION

There is a stream running through the Echo water shed

From a site inspection the ground cover is "Forest with Heavy Ground Litter & Meadow" $C_N = 600$ & the stream has irregular side slopes and the bottom

& the cross section of the stream is filled with large growth

∴ take Manning $n = 0.06$

The cross section of the stream will be approximated as
slope of the stream

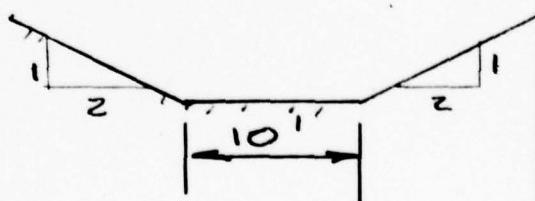
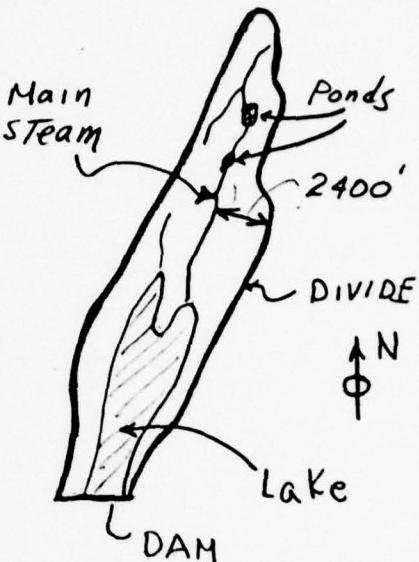
$$S_o = .0024$$

slope of the side of the river basin to the east & west of the main stream

$$S \cong 6\%$$

From SCS Tech Rel # 55

Determine T_c



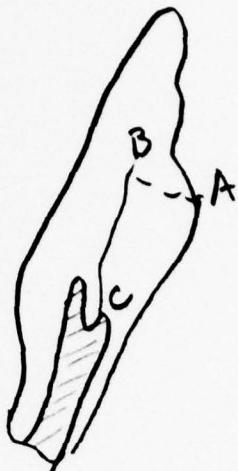
BY JC DATE 8/25 Echo
CHECKED DATE 8/30

JOB NO. J-783
SHEET NO. 2 OF 13

A assume overland flow from A to B and stream flow from B-C

Fig 3-1, vel = 0.62 fPS

$$T_{AB} = \frac{2400}{(0.62)3600} = 1.08 \text{ hr}$$



We estimate that an approximate average value of Q in the stream during Tc is

6000 c f s

$$Q = \frac{1.49}{n} AR^{2/3} S_0^{1/2}$$

$$6000 = \frac{1.49}{.06} (AR^{2/3}) (.0024)^{1/2}$$

$$\therefore AR^{2/3} = 4931$$

The depth of flow $\cong 20'$

$$\text{Area} = 10(20) + 2\left(\frac{2(20)(20)}{2}\right) = 1000 \text{ ft}^2$$

$$\text{vel in stream} = \frac{6000}{1000} = 6 \text{ fPS}$$

$$T_{BC} = \frac{L_{BC}}{\text{vel}} = \frac{7000}{6(3600)} = 0.32 \text{ hr}$$

$$T_c = T_{AB} + T_{BC} = 1.08 + .32 = \underline{1.4 \text{ hr}}$$

B Determine T_c from Fig 3-3
avg slope of the water shed $\approx 4\%$

Take $l \approx 12,000$ feet

$$\therefore \text{Lag Time} = 1.4$$

$$\therefore T_c = \frac{1.4}{0.6} = 2.3 \text{ hr}$$

Choose

$$T_c = 1.4 \text{ Hours}$$

DETERMINE TIME OF PEAK

$$T_p = \frac{D}{2} + 0.6 T_c$$

Take $D = 20 \text{ min}$

$$T_p = \frac{.33}{2} + .6 (1.4) = \underline{\underline{1 \text{ hr}}}$$

$$T_p = 1.0 \text{ HOUR}$$

UNIT HYDROGRAPH

Take q_p from SCS formula

$$q_p = \frac{184.4}{T_p} = \frac{484(3.18)}{1} = \underline{\underline{1539 \text{ cfs}}}$$

BY JC DATE 8/25 Echo

JOB NO. J-783
SHEET NO. 4 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

a curvilinear hydrograph may be constructed from values of g_p and T_p by using ratios tabulated in "Design of small Dams" pg 74, take the time increment = 1

HOURS	T/T_p	g/g_p	UNIT HYDROGRAPH g (cfs)
.33	.33	0.18	277
.67	.67	0.74	1139
1.0	1.0	1.00	1539
1.33	1.33	0.83	1277
1.67	1.67	0.51	785
2.0	2.0	0.32	492
2.33	2.33	0.20	308
2.67	2.67	0.12	184
3.00	3.00	0.075	115
3.33	3.33	0.044	68
3.67	3.67	0.024	37
4.0	4.0	0.018	28
4.3	4.3	0.016	24

$$\Sigma g = 6273 \text{ cfs}$$

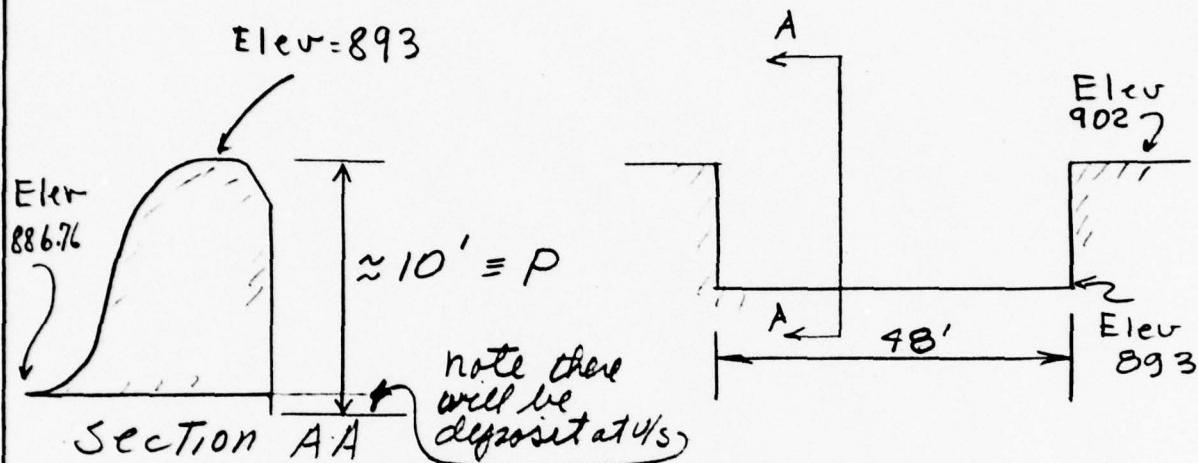
$$\text{Area Under unit graph} = \frac{6273(.33)(3600)(12)}{2033(43,560)} = \underline{\underline{1.01}}$$

BY JC DATE 8/25 ECHO _____
CKD _____ DATE _____

JOB NO. J-783
SHEET NO. 5 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

Spillway Capacity



$$Q = C_o L H^{3/2}, \quad L = 48'$$

Determine C_o from "Design of Small Dams", pg 378 - ogee crest!

Elev	H (ft)	H/P	C_o	(cfs)
893	0	0	0	0
894	1	.1	3.4	163
895	2	.2	3.55	482
896	3	.3	3.68	918
897	4	.4	3.75	1440
898	5	.5	3.8	2039
899	6	.6	3.83	2681
900	7	.7	3.85	3423
901	8	.8	3.86	4192
902	9	.9	3.87	5016

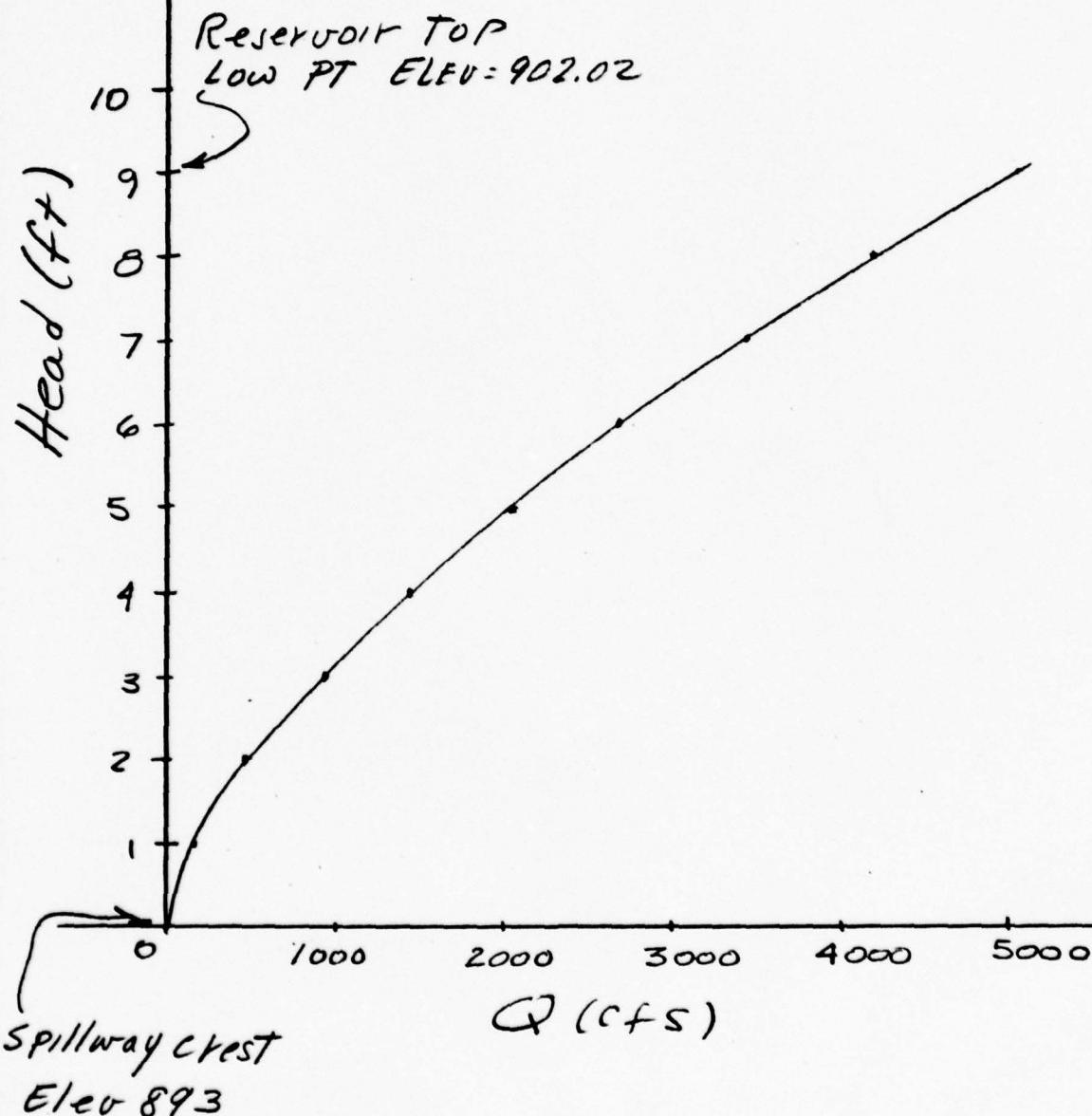
BY JC
CKD *RED*

DATE 8/25 ECHO
DATE 8/30

JOB NO. J-783
SHEET NO. 6 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

Spillway Capacity Curve



BY JC DATE 8/25 Echo

CKD CED DATE 8/30

JOB NO. J-783

SHEET NO. 7 OF 13

Reservoir Storage Capacity

Assume a linear distribution for
 the increase of the area with elevation.
 Start at a zero storage at the crest of
 the spillway

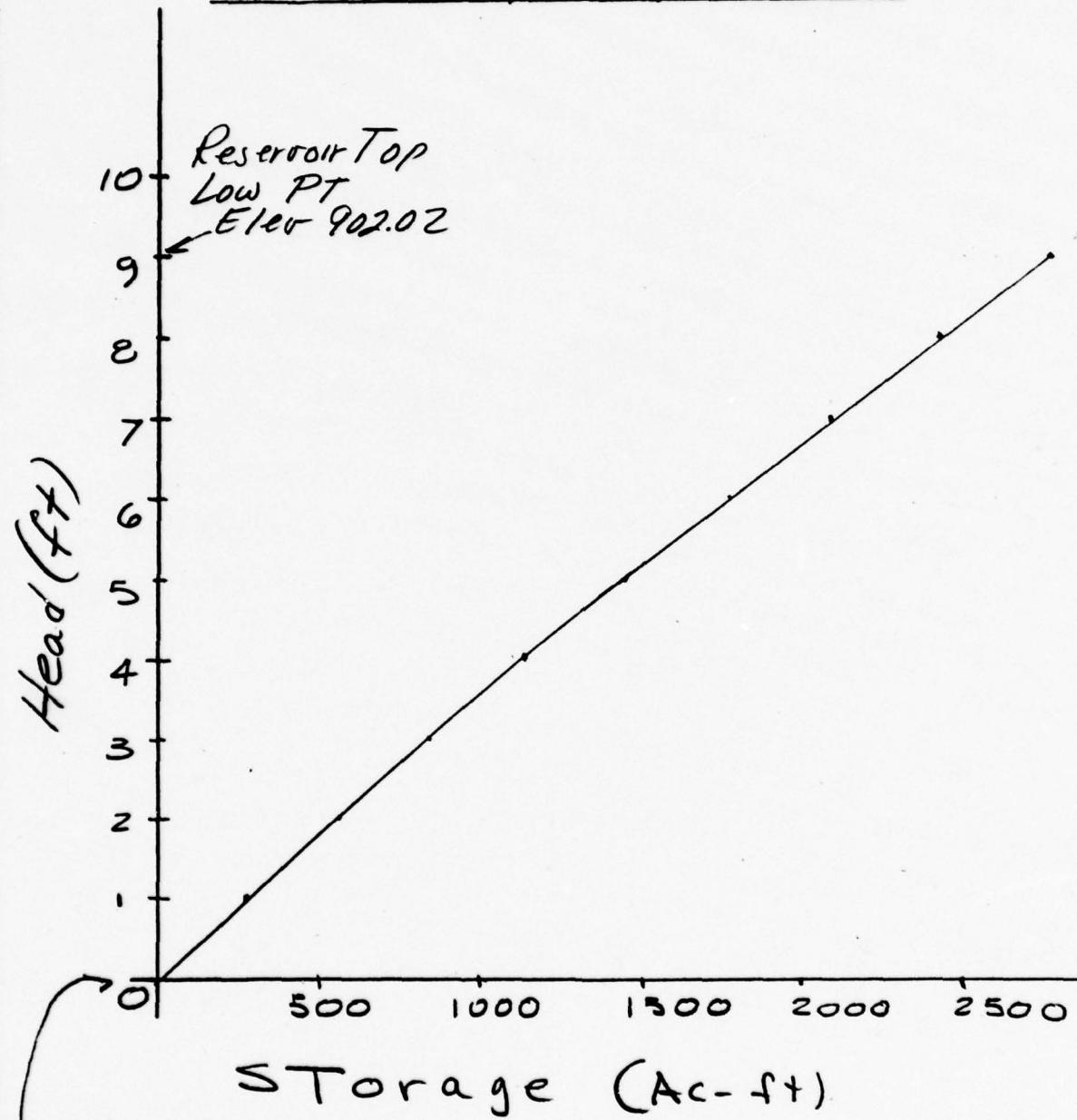
$$\text{Lake area} \approx 270 \quad \text{Elev} = 893$$

$$\text{Area Elev } 900 = 326 \text{ ac}$$

Elev ft.)	Ht (ft.)	Area (Acres)	Avg Area (Acres)	Storage (Ac-ft.)
893	0	270	270	0
894	1	278	274	274
895	2	286	282	556
896	3	294	290	846
897	4	302	298	1144
898	5	310	306	1450
899	6	318	314	1764
900	7	326	322	2086
901	8	334	330	2416
902	9	342	338	2754

LANGAN ENGINEERING ASSOCIATES, INC.

Storage Capacity Curve



BY JC DATE 8/25 ECLD

JOB NO. J-783
SHEET NO. 9 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

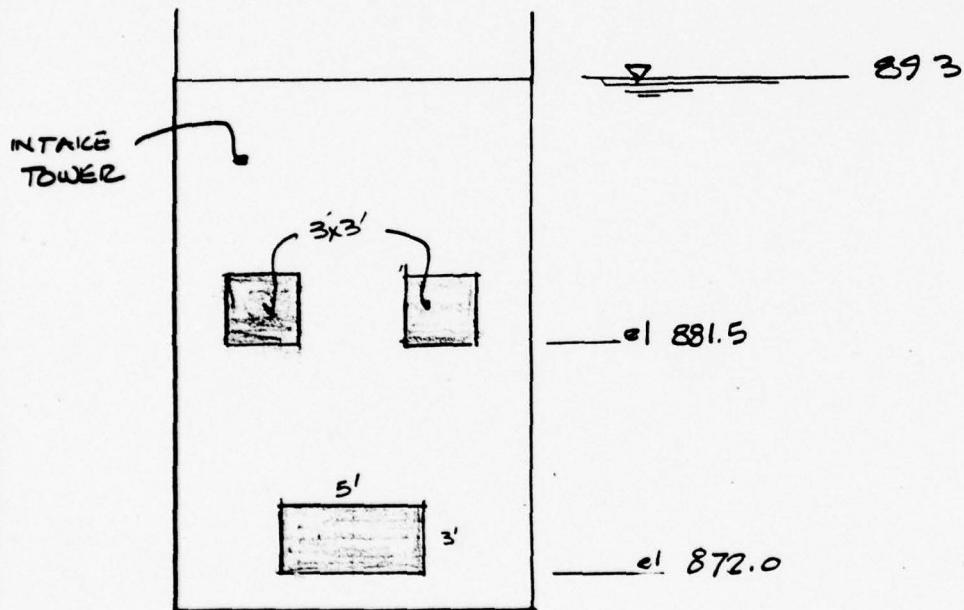
Elev	H	Q cfs	Storage ac ft
893	0	0	0
894	1	163	274
895	2	482	556
896	3	918	846
897	4	1440	1144
898	5	2039	1450
899	6	2681	1764
900	7	3423	2086
901	8	4192	2416
902	9	5016	2754

HYDROGRAPH & FLOOD ROUTING

1. Hydrograph and flood routing determined using HEC 1
2. PMF = 11920 cfs (routed to 4055 cfs)
3. Routing indicates water level will rise to el 901 under PMF leaving approximately 1 ft of freeboard.

DRAWDOWN

1. Outlet structure has two intake openings located at different elevations as shown below. The gates are controlled so that they cannot be opened simultaneously. For purposes of emergency drawdown assume only lower gate will be used. Outlet pipe consists of two 5'x5' box culverts



2 Storage between el 872 + el 893 = 4867 ac-ft

(from available design documents)

3. Opening acts as orifice

$$Q = CA \sqrt{2gH} \quad C = 0.60$$

$$Q = (0.6)(15) \sqrt{2gH}$$

$$Q = 9 \sqrt{2gH}$$

$$Q = 72.2 H^{1/2}$$

BY GED	DATE	7/27	Echo Lake
CKD GED	DATE	8/30	

JOB NO.	J-783
SHEET NO.	11 of 13

LANGAN ENGINEERING ASSOCIATES, INC.

ft	H	20	16	12	8	4	0
cf	Q	322	288	250	204	144	0

4. Check capacity of outlet pipes

Size: Twin 5x5

Length = 105'

Slope = .02%

n = .012 (concrete)

$$\frac{L}{100s_0} = \frac{105}{100(0.02)} = 5.250$$

∴ outlet control

use HEC circular No 10 chart 3

H ft	20	16	12	8	4	0
Q cfs	175	440	350	260	100	

5 Conclusion - Intake Tower opening controls flow

6. Storage

Assume area varies with height $A(z) = 270 \text{ acres}$

$$\begin{aligned} \text{Area changes per ft} & \quad \left[\frac{(270+x)}{z} z = 4867 \right] \quad x = \text{area @ bottom} \\ \frac{270-193}{z} = 3.67 \text{ ac/ft} & \quad x = 193 \end{aligned}$$

Elev	Acres	Δ Storage	Total Storage
893	270		
892	266.3	268.1	4859.1
888	251.6	1035.8	4591.00
884	236.9	977.0	3555.2
880	222.2	918.2	2578.2
876	207.5	859.4	1660.5
872	192.8	800.6	800.6

$$7 \quad \text{inflow} = 2 \text{ cfs / sq mi}$$

$$273 \times 2 = 5.46$$

DATE 7/21 Echo Lake
TIME 8:30

JOB NO. J-783
SHEET NO. 12 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

Elev	Q_{out}	$Q_{out \text{ avg}}$	Q_{net}^*	Storage	Δt	$\Sigma \Delta t$ hrs	$\Sigma \Delta t$ days
893	332	327	322	268	10	2.1	
892	322	305	300	1036	44	4.0	
888	288	269	264	977	45	6.0	
884	250	227	222	918	50	8.5	
880	204	174	169	860	59		
876	144	72	67	800	144		
872	0						

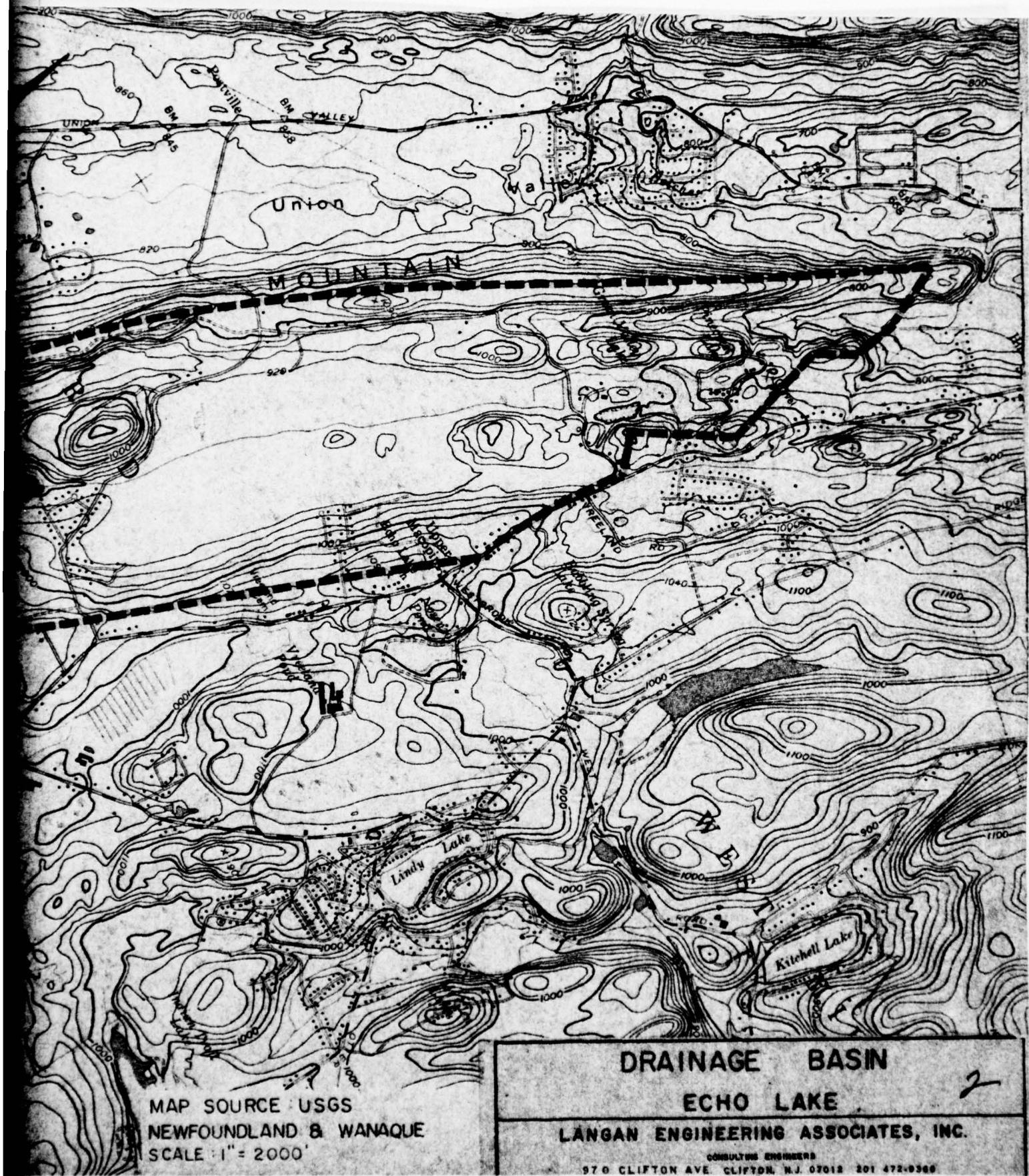
* $Q_{net} = Q_{out \text{ avg}} - 5 \text{ cfs}$

*

BY GED DATE _____ Echo
 CKD GED DATE 8/30 _____

JOB NO. J-783
 SHEET NO. 13 OF 13





HEC-1 OUTPUT

ECHO LAKE DAMS

width 132
listcf ech20 'breakdown'-
PCM20 12:51 AUG 30, '78
AM0509 JDN 3307 (LAMC0514) IN BREAKDOWN
CDC18 LAMC0514 3307 PR06P001 12-01-01 30 AUG 78 CED

RDC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

RDC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

listcf ech20 'breakdown'-
PCM20 12:51 AUG 30, '78
AM0509 JDN 3307 (LAMC0514) IN BREAKDOWN
CDC18 LAMC0514 3307 PR06P001 12-01-01 30 AUG 78 CED

RDC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

RDC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

ECHO DAM
DETERMINING INFLOW HYDROGRAPH AND ROUTE RMP-2000 DAM
N.J. DAM INSPECTION

NO	MIN	MIN	DAY	INR	ININ	METRIC	IPMT	IPMT INSTAN
150	0	20	0	0	0	0	0	0
			JOPEN	WRT				
			3	0				

JOB SPECIFICATION

70	0.00	0.00
71	0.00	0.00
72	0.00	0.00
73	0.04	0.00
74	0.04	0.00
75	0.04	0.00
76	0.04	0.00
77	0.04	0.00
78	0.04	0.00
79	0.04	0.00
80	0.04	0.00
81	0.04	0.00
82	0.04	0.00
83	0.04	0.00
84	0.04	0.00
85	0.04	0.00
86	0.04	0.00
87	0.04	0.00
88	0.04	0.00
89	0.04	0.00
90	0.04	0.00
91	0.11	0.04
92	0.11	0.04
93	0.11	0.04
94	0.11	0.04
95	0.11	0.04
96	0.11	0.04
97	0.11	0.04
98	0.11	0.04
99	0.11	0.04
100	0.11	0.04
101	0.11	0.04
102	0.11	0.04
103	0.11	0.04
104	0.11	0.04
105	0.11	0.04
106	0.11	0.04
107	0.11	0.04
108	0.11	0.04
109	0.67	0.61
110	0.67	0.61
111	0.67	0.61
112	0.61	0.74
113	0.61	0.74
114	0.61	0.74
115	1.01	0.94
116	1.01	0.94
117	1.01	0.94
118	2.55	2.49
119	2.35	2.49
120	2.45	2.46
		16308.

5

121	0.94	0.87	11920.
122	0.94	0.87	11342.
123	0.94	0.87	9648.
124	0.74	0.67	8025.
125	0.74	0.67	6827.
126	0.74	0.67	5907.
127	0.05	0.00	5076.
128	0.05	0.00	3959.
129	0.05	0.00	2683.
130	0.05	0.00	1689.
131	0.05	0.00	1016.
132	0.05	0.00	617.
133	0.05	0.00	357.
134	0.05	0.00	220.
135	0.05	0.00	137.
136	0.05	0.00	86.
137	0.05	0.00	41.
138	0.05	0.00	23.
139	0.05	0.00	6.
140	0.05	0.00	6.
141	0.05	0.00	6.
142	0.05	0.00	6.
143	0.05	0.00	6.
144	0.05	0.00	6.
145	0.0	0.0	6.
146	0.0	0.0	6.
147	0.0	0.0	6.
148	0.0	0.0	6.
149	0.0	0.0	6.
150	0.0	0.0	6.
SUM	25.47	19.91	126846.

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
INCHES	11920.	6273.	1734.	846.	126846.
AC-FT		18.35	20.29	20.42	20.62
		3112.	3442.	3497.	3497.

HYDROGRAPH ROUTING

ROUTING COMPUTATIONS		ROUTING DATA		JFMT		JPT		INAME	
1STAQ	ICOMP	1ECOM	ITAPZ	0	0	0	0	1	1
1	1	0	0						
GLOSS	CLOSES	AVG	TRCS	TRME	TRME	TRME	TRME	TRME	TRME
0.0	0.0	0.0	1	0	0	0	0	1	0

6 6
46 6 6
47 9 20.
48 11. 94.
49 18. 229.
50 26. 319.
51 35. 297.
52 40. 216.
53 44. 144.
54 47. 96.
55 49. 62.
56 50. 40.
57 51. 28.
58 51. 22.
59 52. 16.
60 52. 12.
61 52. 9.
62 52. 7.
63 53. 7.
64 53. 6
65 53. 6
66 53. 6
67 53. 6
68 54. 6
69 54. 6
70 54. 6
71 54. 6
72 54. 6
73 54. 6
74 55. 6
75 55. 6
76 55. 6
77 55. 6
78 55. 6
79 55. 6
80 56. 6
81 56. 6
82 56. 6
83 56. 6
84 56. 6
85 57. 6
86 57. 6
87 57. 6
88 57. 6
89 57. 6
90 57. 6
91 58. 6
92 59. 43.
93 62. 101.
94 65. 162.
95 77.

131.	76.	211.	0.
97.	85.	252.	0.
96.	92.	262.	0.
96.	99.	269.	0.
100.	107.	273.	0.
100.	115.	276.	0.
102.	123.	278.	0.
103.	130.	279.	0.
109.	175.	357.	50.
104.	138.	279.	9.
110.	194.	755.	72.
105.	145.	279.	17.
106.	152.	279.	25.
107.	159.	279.	33.
108.	166.	279.	41.
109.	175.	357.	50.
110.	194.	755.	72.
111.	233.	1508.	116.
112.	292.	2318.	184.
113.	368.	2992.	270.
114.	457.	3531.	370.
115.	555.	3973.	480.
116.	660.	4393.	639.
117.	773.	4832.	809.
118.	898.	5435.	1009.
119.	1054.	6809.	1283.
120.	1263.	9054.	1873.
121.	1516.	11116.	2179.
122.	1769.	11631.	2693.
123.	1978.	10495.	3173.
124.	2124.	8836.	3523.
125.	2233.	7426.	3766.
126.	2302.	6367.	3927.
127.	2364.	5492.	4055.
128.	2357.	4518.	4055.
129.	2338.	3321.	4010.
130.	2289.	2186.	3896.
131.	2221.	1353.	3738.
132.	2443.	816.	3556.
133.	2031.	487.	3166.
134.	1979.	289.	3177.
135.	1899.	178.	2992.
136.	2029.	112.	2815.
137.	1822.	64.	2650.
138.	1749.	32.	2506.
139.	1678.	14.	2370.
140.	1548.	6.	2240.
141.	1489.	6.	2118.
142.	1432.	6.	2084.
143.	1378.	6.	1899.
144.	1328.	6.	1799.
145.	1280.	6.	1705.

AD-A058 839 NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. ECHO LAKE INTAKE DAM. (NJ-00315). --ETC(U)
AUG 78 D J LEARY

DACW61-78-C-0124

NL

UNCLASSIFIED

2 of 2
AD
A058 839



END
DATE
FILED
-1-78
DDC

listcf echo10 'breakdown'~

ECHO10 12:44 AUG 30, '78
ANDS09 JOB 3303 (LANS0512) IN BREAKDOWN
LANS0512 3303 PT06P001 12:00:53 30 AUG 78 GED
CDC18 *****

REC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

REC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

ECHO DAM
DETERMINING INFLOW HYDROGRAPH AND ROUTE & PMP-ECHO DAM
N.J. DAM INSPECTION

JOB SPECIFICATION
HQ MHR MHTN IDAY IHR IRIN METAC IPUT IPUT INSTAN
150 0 20 0 0 0 0 0 0 4 0
JOPER MHT
5 0

MULTI-PLAN ANALYSES TO BE PERFORMED
MPLAN1 MPLAN2 LATION1

MTOSE 1.00 0.50 0.40 0.30 0.20 0.10

SUB-AREA RUNDOWN COMPUTATION

COMPUTE ATTRIBUTES		INTERPOLATE DATA						PRINCIPAL DATA	
NAME	TYPE	SCOMP	ISCOMP	ITIME	ITIMEP	ISPLT	ISPLTP	ISAVE	ISAVEP
RNGC	REAL	0.0	0	0	0	0	0	0	0
RNGS	REAL	0.0	0	0	0	0	0	0	0
SPLT	REAL	3.15	0	3.15	0	0	0	0	0
SPLTP	REAL	0.0	0	0.0	0	0	0	0	0
SAVE	REAL	0.0	0	0	0	0	0	0	0
SAVEP	REAL	0.0	0	0	0	0	0	0	0
SAVEC	REAL	0.0	0	0	0	0	0	0	0

STATION	LATITUDE	LONGITUDE	LOSS DATA			CIRCUIT	ALARM	RTIME
			MAIN	STRESS	WIND			
0-0	0-0	1-00	0-0	0-0	1-00			
ELECTION DATA								
STATION	-2-00	0-00000	0-0			RTIME 0-1-00		
END-OF-PERIOD FLOW								
TIME	RAIN	ICE	CMP 0					
0000	25.47	19.91	126846.					

.....
.....
.....
.....
.....

P2PU PRO SUPPORT FOR MULTIPLE PLAT-MIXED ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	1.00	0.50	0.40	0.30	0.20	0.10
HYDROGRAPHIC	AT	1	11920.	5960.	4760.	3576.	2384.	1192.
ROUTED TO	1	2	0.	0.	0.	0.	0.	0.

MCDONNELL DOUGLAS AUTOMATION COMPANY -- ST. LOUIS MESSAGE OF THE DAY

THE ST. LOUIS AIRPORT STATES WILL DISCONTINUE OPERATIONS AT 0630, SUNDAY, 3 SEPTEMBER. NORMAL OPERATIONS WILL RESUME AT 0130, TUESDAY, 5 SEPTEMBER.

HAVE A HAPPY IDAY.

McDONNELL DOUGLAS AVIATION COMPANY -- ST. LOUIS
COMPUTER SYSTEMS 571
OS MVT RELEASE 21.7

CLINICAL CASES 20

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*** NEW LIMITS ***
CPU (MHz) .56 DEFAULT PROGRAMMER NAME FIELD
I/O (MHz) 1.00 DEFAULT JES BENCHMARK SYSTEM
CPU
```

APPENDIX 5

REFERENCES

ECHO LAKE DAMS

APPENDIX 5

REFERENCES

ECHO LAKE DAMS

Written Documents

- | | | |
|-----|--|--------------------------|
| 1. | Report of Hydraulic Engineer to
Mr. James W. Costello
Chief Engineer
Department of Public Affairs
Newark, New Jersey | Dated March 14, 1926 |
| 2. | Letter to The Department of
Conservation and Development
Trenton, New Jersey
By James W. Costello | Dated April 22, 1926 |
| 3. | Sketch of Watershed Area | |
| 4. | Extract from Specifications | |
| 5. | Photos before 1926 Construction (3) | Dated April 29, 1926 |
| 6. | Report on Dam Inspection by
John N. Brook | Dated September 20, 1926 |
| 7. | Monthly Progress Report | Dated September 30, 1926 |
| 8. | Monthly Progress Report | Dated October 31, 1926 |
| 9. | Report on Dam Inspection by
John N. Brook | Dated April 15, 1927 |
| 10. | Photos (4) | Dated April 14, 1926 |
| 11. | Letter to: James W. Costello
From: H.P. Kummel
Department of Conservation &
Development | Dated April 18, 1927 |
| 12. | Photo | Dated May 26, 1927 |
| 13. | Report on Dam Inspection | Dated May 18, 1928 |
| 14. | Photos | Dated May 16, 1928 |

APPENDIX 5 Cont'd

ECHO LAKE DAMS

Drawings

1. Plan of Echo Lake Improvement, February 1897
2. Blasting Outlet channel in Echo Lake Reservoir, May 1950
3. Location of Spillway and Intake Structure
4. Borings and Geology
5. Plan View of Diversion Channel, Spillway Channel and Earth Dam
6. Cross Sections of Spillway Channel and Diversion Channel
7. Spillway and Abutments Sections

Others

1. Eby, C.F. 1976, Soil Survey of Morris County, New Jersey, U.S. Department of Agriculture, Soil Conservation Service, 111 pp.
2. Lewis, J.V. and H.B. Kummel, 1924, The Geology of New Jersey, Bulletin 14, Geological Survey of New Jersey, Trenton, New Jersey, 146 pp.
3. Lucey, C.S., 1972, Geology of Morris County in Brief, State of New Jersey, Bureau of Geology and Topography, Trenton, New Jersey, 13 pp.
4. Minard, J.P. W.W. Holman, A.R. Jumikis, 1953, Engineering Soil Survey of New Jersey, Report No. 9, Morris County, Rutgers University, New Brunswick, New Jersey, 86 pp.
5. Rogers, F.C., D.R. Lueder, and G.H. Obear, 1951, Engineering Soil Survey of New Jersey, Report No. 3, Passaic County, Rutgers University, New Brunswick, New Jersey, 45 pp.
6. Widmer, K., 1964, The Geology and Geography of New Jersey, Volume 19, The New Jersey Historical Series, D. Van Nostrand Co., Inc., Princeton, New Jersey 193 pp.
7. Wolfe, P.E., 1977, The Geology and Landscapes of New Jersey, Crane, Russak & Company, Inc., New York, New York, 351 pp.